THE

# FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 48. Thursday, April 13, 1933. No. 869.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

## Contents.

| | PAGE |
|---|---|
| Forthcoming Events | 249 |
| Iron and Steel Reorganisation | 249 |
| Annual Meeting of the American Gray Iron Institute | 250 |
| District Presidents.—No. 12 | 250 |
| Book Review | 250 |
| Random Shots | 250 |
| Deep-Joint Elimination | 251 |
| Bronze Tuyeres | 252 |
| Foundry Education | 253 |
| Modern Patternmaking | 255 |
| High-Tensile Steel Castings | 256 |
| Insulating Refractories | 256 |
| The Sand Question in Regard to Light-Casting Production | 257 |
| This Week's News in Brief | 262 |
| Trade Talk | 262 |
| Company Reports | 262 |
| New Companies | 262 |
| Personal | 262 |
| Raw Material Markets | 264 |
| Calendars Received | 264 |

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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## Forthcoming Events.

APRIL 19.
*Institution of Welding Engineers*:—Meeting in London. "Improvements in Welding Practice," Paper by or on behalf of Prize-winner.

MAY 1.
*Society of Chemical Industry (London Section)*:—"Recent Developments in Metallurgy," Paper by Prof. C. H. Desch.

**Institute of British Foundrymen.**

APRIL 15.
*Lancashire Branch (Junior Section)*:—Ordinary meeting at Manchester. Short Paper Competition.

APRIL 21.
*Sheffield and District Branch*:—Annual general meeting at Sheffield. "The Technical Committee and Technical Developments in the Foundry Trade," Paper by J. R. Hyde and T. R. Walker.

APRIL 27.
*Newcastle-upon-Tyne and District Branch*:—Annual general meeting at Newcastle-upon-Tyne. Papers by competitors successful in the competition on January 25.

APRIL 29.
*West Riding of Yorkshire Branch*:—Annual general meeting at Technical College, Bradford.

## Iron and Steel Reorganisation.

The elaborate scheme which has been made public for the reorganisation of the iron and steel industry has aroused a good deal of interest, and the published comments show the difficulties with which the preparation of the scheme has been accompanied. The National Federation of Iron and Steel Manufacturers, itself the result of the merging of several associations under pressure of war-time conditions, will be replaced by an Iron and Steel Corporation of Great Britain which will co-ordinate the work of a number of sectional associations formed out of 50 or so existing associations, but fewer, more compact and directed towards the concentration of production in the more efficient plants and towards the development of export trade. The Corporation will not own or operate any works or interfere with any individual producer.

Eleven main associations representing the major sections of the industry will be organised, including pig-iron and ferro alloys, wrought iron, steel castings and the various sections of the steel trade. The funds of the Corporation will be derived from an annual levy per ton on pig-iron and ingot steel from makers of those products and otherwise from a levy on wages from all other members.

The foundry industry is keenly concerned with this development for various reasons. The new Corporation will be the source from which the industry will derive its pig-iron and ferro-alloys, and probably all makers of these products and many makers of refined iron will be in the Corporation, although some makers of refined iron probably will not. Secondly, the position of the foundry industry in relation to the iron and steel industry has always been curious and in some respects anomalous. As a consumer of pig-iron the foundry industry is of vital importance to the iron and steel industry and indeed forms an integral part of it. As a consumer of ingot moulds and other castings, the heavy industries are very important to the foundry industry; so much so that many works in the Corporation-to-be have foundries. At the same time castings are widely made in or for the engineering and building industries which normally do not come within the scope of the iron and steel industry. Steel castings are in the heavy group and will be dealt with by one of the new associations, but their manufacture again is not confined to the new Corporation nor could it be so confined. Has serious thought been given, by the leaders of the industry both within the foundry industry and within the iron and steel industry, to the relationship between these two branches?

Candidly, we do not think that adequate thought has been given, because even within the steel-foundry business (which is specifically mentioned) members of the Steel Castings Association hold divergent opinions as to how the scheme will affect them. The attitude of some may be like that of the three dissentient makers of foundry pig-iron who, whilst not objecting to the scheme, *per se*, consider that their interests are not sufficiently identified with those producers of iron and steel to make it desirable that they should participate in the scheme. This non-identification of interests is a factor entirely in the hands of the proposed Corporation. If, for instance, they could compose the differences which have arisen within the steel-foundry industry as to the best method of eliminating price-cutting, then identification of interests would be assured and their co-operation valued. When, however, it relates to the ironfounding interests, the matter becomes infinitely more complicated, as for years we have been trying unsuccessfully to show this industry that there are many interests of common identification. We admit that it is difficult to convince a manufacturer of motor-car cylinders that he has anything in common with an ingot-mould manufacturer.

It is obvious that the foundry industry cannot be dealt with like the steel industry, for rails, tyres, girders, plates, sheets, angle-irons and the like are all more or less standardised, whereas, apart from a few jobs such as pipes, axleboxes, chairs, colliery-tub wheels and a few other lines, castings are still of a very diverse character. However, we note that special steels come within the purview of the proposed Corporation, and if this problem can be solved satisfactorily, then no doubt the principles evolved could be applied equally well to the foundry industry. The nature of the co-operation may be merely to ensure that the actions of the Corporation will not damage any section of what is embraced within the general classification "iron and steel industries." If this be so, there is at least much to be gained by the sections of the ferrous foundry industry claiming representation immediately, but if the rationalisation of the iron and steel industry is to embrace the rationalisation of the foundry industry, then much more information is required than has been made available to the public.

The foundry industry is probably as large as the iron or steel industry, and for the success of their scheme the Corporation would be wise to enlist its co-operation from the inception of its activities. If it can help to assure better prices for castings, its help will be enthusiastically acclaimed by more than 3,000 foundry directorates and owners.

XUM

## Annual Meeting of the American Gray Iron Institute.

At the annual meeting of the Gray Iron Institute, at Cleveland, various problems of interest to the grey-iron industry were discussed. The meeting was divided into four sessions, devoted to cost, technical subjects, merchandising and insurance.

Mr. A. E. Hageboeck, Frank Foundries Corporation, Moline, Ill., was re-elected president for the following year. Mr. J. H. Bruce, Bowler Foundry & Machine Company, Cleveland, was elected vice-president, succeeding J. L. Carter, Newark, N.J. Mr. E. B. Sherwin, Chicago Hardware Foundry Company, North Chicago, Ill., was elected second vice-president. Mr. R. D. Phelps, Francis & Nygren Foundry Company, Chicago, was appointed treasurer, and Mr. H. C. Wilson, Cleveland Co-operative Stove Company, Cleveland, assistant treasurer.

A brief review of the work accomplished since the association was formed five years ago was made by Mr. Hageboeck. He urged the importance of a definite programme and individual contacts by the manager with members in order to obtain their views for transmission to the board as to work that should be undertaken. Mr. B. H. Johnson, of Messrs. R. J. Wood & Company, Philadelphia, past-president, stressed the importance of research and development work, mentioning in this connection that the manufacture of automobile cam and crankshafts of cast iron and various other new cast products was the result of development work.

### Technical Session.

The technical session opened with a review of work of the technical committee, with particular reference to the new specifications A48-32T for grey-iron castings now in force, which was presented by Mr. Coltman, whose topic was "The Forward March of Grey Iron." The preparation of test specimens, he said, had been recommended with a view to establishing correct classifications, the influence and relation of test-bars to standards, the elevation of the standards of grey iron and the certification plan. The third factor, elevating the standards of grey iron, he said, was accomplished in the same specifications by introducing the physical properties and ranges which were found by actual survey of the products of members. This work, he declared, was the most decided advance of grey iron toward a position of respect in the eyes of the engineering profession in over 20 years. Discussing the new specifications from the foundry viewpoint, Mr. Ziebell urged the need of raising and improving standards.

### Damping Qualities.

A report on physical properties of grey iron for light structures by Mr. Sherwin, of the light grey-iron sub-committee, was read. This committee was appointed to investigate the physical properties of typical light castings, because it was felt that properties other than tensile strength became more important as sections become thinner.

Interest was shown in recently-announced developments in tests for damping capacity. Rigidity and damping qualities were considered of importance when grey-iron castings are being compared with stampings, for example. Most grey-iron consumers, the report stated, suppose that the superiority of grey iron is merely due to its greater weight. This, however, is only partly true, as recent experiments show that the efficiency of grey iron in damping vibration regardless of weight is 12 times as great as steel and 20 times as great as aluminium. In the discussion, Mr. Coltman stated that there is less vibration in low-carbon iron than in that having a higher carbon content. Mr. Tuscany expressed the opinion that damping tests offered a real opportunity both for engineers and salesmen.

## District Presidents.—No. 12.

### LEICESTER ASSOCIATION OF ENGINEERS.

Mr. Sydney J. Perry, who has been elected President of the Leicester Association for the second year in succession, is a partner in the well-known firm of patternmakers, G. Perry & Sons, of Thornton Lane, Leicester. Mr. Perry was educated at Leicester College of Technology. About 30 years ago he entered his father's works, which has some notable achievements to its credit, such as some of the world's largest turbines and generators; pump casings cast in one piece weighing about 20 tons, and the engine patterns for the Rolls-Royce aero engines. Under Mr. Perry's guidance the Leicester Association has been particularly successful, as the average attendance at its weekly lectures has been about 150 with 75 participants in the various works visits which have been arranged.

Mr. Sydney J. Perry.

## Book Review.

**Recommended Methods for Sampling and Analysis of Cast Ferrous Metals and Alloys.** Published by the British Cast Iron Research Association, 21 to 23, St. Paul's Square, Birmingham. Price 10s. 6d.

This is not the first occasion upon which the Research Association has published a book of this type. Actually, in 1929, it published a report, of which the one under review is virtually the second edition, and the rapid exhaustion of that publication clearly demonstrates its usefulness. In a preface, Mr. J. G. Pearce very rightly stresses the advisability of the use of standardised samples of irons.

The book, which contains about 44 pages, first outlines the methods to be used for the preparation of samples for analysis, and briefly reviews the determination of all the elements likely to be found in cast iron, whether ordinary or special, except arsenic. The comments made are thoroughly practical and can easily be followed by the average foundry chemist. The last section of the book is devoted to polishing and etching samples for microscopic examination. Once again the subject is sympathetically treated and will be of the greatest use to those in isolated laboratories. We can thoroughly recommend this book as being excellent value for money.

## Random Shots.

The educational film seems to be increasing rapidly in popularity, particularly in the welding industry. Members of the Institution of Welding Engineers, at their next meeting, are to witness three such films, depicting automatic metal arc welding, automatic flash-butt (resistance) welding and oxy-acetylene welding. The meeting should attract a record house.

* * *

Exponents of the blowpipe, however, are not alone on the "production floor." From a correspondent "Marksman" learns that Mr. George Watley, the manager of Messrs. R. & A. Main, Limited, is an enthusiastic cinematographer, and that the firm has been experimenting for several months with the movie camera. So successful have they been, indeed, that one of their films was exhibited recently to the Royal Photographic Society in London. Fifteen-hundred watt lamps are used in the foundry when "shots" are being taken, the battery of lamps giving a total of 11,000 watts. An illuminating object lesson to the owners of badly-lighted foundries!

* * *

Miss Nellie Snookers has once again been safeguarding the interests of the foundry interest. In a lengthy epistle (dated—is this significant?—April 1) she exposes the machinations of the Anti-Foundry Propagandists. Her agents advised her that the Propagandists were to hold an important conference in a disused brewery in Wapping. Miss Snookers continues: "I arrived at the brewery an hour before the time of the meeting, Amelia (my private secretary) accompanying me. We climbed to the roof of the brewery and pulled up a sack of mixed soot and pepper, and then awaited the arrival of the Propagandists. They were not very punctual. An ex-politician, disguised as an Italian ice-cream seller, was the first to appear. At intervals of several minutes he was joined by a dozen or so fellow-conspirators. The light was not good, and I found it difficult to recognise them. One, I thought, rather resembled a taxi-cab driver I saw in Lowestoft once.

* * *

"They sat down in a ring on old casks just underneath the skylight where I and Amelia were perched. And, believe me, we heard the most appalling plots. They actually began to discuss the possibility of distributing anti-foundry propaganda at the Foundry Trades' Exhibition. That was more than I could endure. We manœuvred the mouth of the sack through a broken pane in the skylight and up-ended the sack. Miltonic chaos followed for several moments; then the conspirators fled in a cloud of soot and pepper. Later, on the brewery floor we found a drop forging marked A.B.C., a pressing with the initials X.Y.Z., a plastic moulding (shaped rather like a door-knob) and a cigarette end with a mauve silk tip. We are now following up these clues; also the trail of pepper and soot that marked the flight of the Propagandists."

* * *

A woman who particularly wished to go to a dance arranged for a highly-recommended young lass to take care of her children. When the mother returned she asked the girl whether she had had any difficulty with the family.

"Well," said the buxom lass, "the eldest boy, the red-headed one, was a bit of a handful. I had to use force to get him into bed."

"Red-headed one!" shrieked the mother. "Heavens, that's my husband!"

Marksman.

# Deep-Joint Elimination.

By F. C. Edwards.

Deep joints and drawbacks may be considered excellent things for testing the moulder's skill. The Victorians revelled in such "exhibition" work. "Leave it to the moulder," complacently remarked the patternmaker of those halcyon days, when (to him) a troublesome moulding problem presented itself, and the "sand artist" usually obliged—uncomplainingly!

To-day, the deep joint is an anachronism. Foundries are no longer "schools of art." "Production" is their watchword; their sole interest—"output." And this, of course, not from choice. It is stark necessity. For the foundry of to-day has not merely to compete, as of yore, with others similarly circumstanced, but is also exposed to ruthless, non-foundry competition. It simply cannot afford to be handicapped.

Mould joints, of course, are determined by the pattern—a vehicle of production, where shape controls speed. The greater the deviation of any joint from its common, horizontal plane, the greater the foundry handicap.

Now it is a primary principle in pattern-making that moulding possibilities should be visualised in relation to the particular job in hand. In this way, by the adoption of the appropriate antidote, one is able generally to nullify whatever casting-design abnormalities may be encountered, and so help the foundry to maintain a winning fight against competitive processes.

The pattenmaker, therefore, who adopts a *laissez-faire* attitude towards mould-joint problems is guilty of inciting the moulder to carve his industry's epitaph! Such nonchalance on the patternmaker's part is the more inexcusable in these days of simplified-core production. "Coring versus moulding," is now a question of entirely different implications from that presented to the Victorians. Then, quite ordinary cores required expensive core irons, many hours—sometimes days—to dry, and honey-combed venting. To-day, special core irons are seldom required. The drying time has been considerably reduced, and venting is mostly a superfluous operation.

### The Advent of the Oil-Sand Core.

The development of the oil-sand core (with its innumerable species) has changed all that. Furthermore, it increasingly permits of profitable exploitation. Through its agency many an otherwise unattainable design has been brought within easy reach of the foundry. It enables the patternmaker, so to speak, to turn castings inside out; to secure internal and external shape with equal facility. Above all, it lends itself to accuracy.

Coring is the answer to deep-joint problems. By its aid one is able to reduce plane variations to a common level. The protuberant boss; the impossible "under-cut"; the straying cast-on (to save machining) bracket; projections galore—curved, or cranky, stout, or lanky—all bow before the omnipotent core!

### Moulding a Cranked Lever.

Coring, again, is still the conveniently appropriate answer in various problems of pattern construction. Through the media of coreprints the patternmaker gives backbone to the otherwise spineless pattern, joins up loose limbs, and turns frailty into strength. An example in which coring serves the dual purpose of eliminating deep joints and aiding pattern construction is illustrated by Figs. 1 to 5. Fig. 1 represents a malleable-iron cranked lever, 2 ft. long, with a general metal section, 2 in. by ⅜ in. Now, to attempt the construction of a pattern of this kind without extraneous support (that is, as a facsimile of the casting), would be simply "asking for trouble"—both in the pattern shop and in the foundry. Such a pattern would not bear handling; and it would certainly not survive its first experience of ramming.

Then there are the mould joints to consider. The job will mould, of course, as shown in plan, at A, Fig. 1. As will be seen in the elevational sketch, the casting deviates on both sides from the common, horizontal plane B. This means, that if the pattern was cranked, like the casting, the moulder would be compelled to joint downwards, and upwards to allow of the withdrawal of the pattern. This, admittedly, is possible. Indeed, if a metal pattern and special box parts were made, it might be considered quite good practice. Metal patterns and special boxes, however, are not presented gratis to the foundry; they involve capital outlay, which could only be justified by quantity production. Here coring provides the most practical answer. It gives a simple-plane joint; it simplifies and strengthens the pattern; and is suitable either for a one-off job, or, if necessary, for a thousand castings.

A general view of the pattern is given in Fig. 2. The coreprints, C, D, E, are shown sectioned. It should be noted, incidentally, that the plywood groundwork of the job is not confined to the shape of casting, plus coreprints, but an outlying portion, F, is allowed to remain. This conveniently serves as a tie-piece between G and H, and confers rigidity on the whole. Since the tie-piece emerges from the coreprints, C and D, it is automatically stopped off as the cores are inserted in the mould. The upper projection, J, is loosely dowelled on the plate, so as to lift off in the top-part box, and thus obviates mould disturbance.

The coreboxes corresponding to the coreprints, C, D, E, are shown in Figs. 3, 4 and 5 respectively. Fig. 3, of course, is easily related to coreprint C. The relationship between coreprints D and E and Figs. 4 and 5, however, is not perhaps so obvious, on account of the absence in the sketch of a view underneath coreprint D. It should be noted that coreprint E projects underneath the bottom of D, and coincides in length with the corebox at K, Fig. 5. This print locates the slot core in the mould. Core D is then inserted in the mould. The necessary slot required in this core to enable the moulder to position it over core E is formed by the internal projecting piece L, Fig. 4. The other internal projection M, in Fig. 4, forms the rib on the underside of the cranked, slotted end at N, Fig. 1. The coreprint D is recessed underneath where this rib is located, and so confines it to its required level. All cores, incidentally, are housed in the drag.

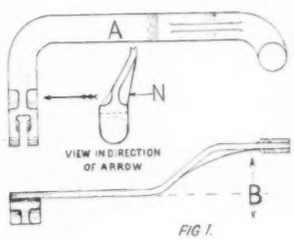

FIG 1.

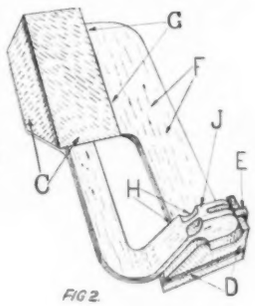

FIG 2.

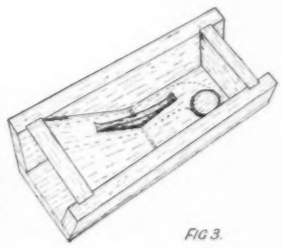
FIG 3.

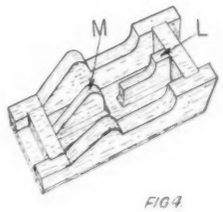

FIG 4.

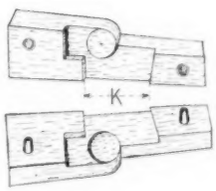

FIG 5.

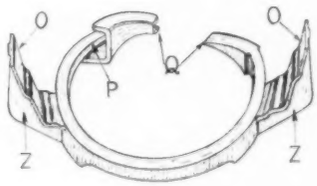

FIG 6.

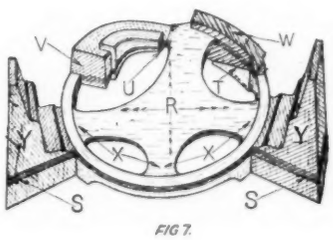

FIG 7.

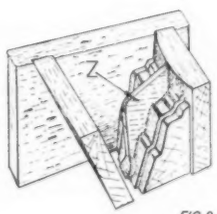

FIG 8.

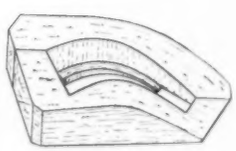
FIG 9.

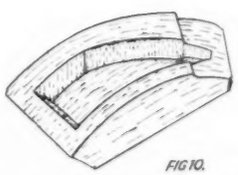
FIG 10.

FIGS. 1 TO 10 SHOW TWO STRIKING EXAMPLES WHERE CORING HAS SIMPLIFIED PRODUCTION PROBLEMS.

### A Second Case.

A further example in which coring obviates deep joints, and converts a difficult casting design into an easy moulding proposition, is

(*Concluded on page* 252.)

## Bronze Tuyeres.

By Robert Jones.

After several unsuccessful attempts were made to produce sound and reliable "bronze tuyere" castings as shown in detail in Fig. 1, due to the practice of using chaplets on the nose end as in Fig. 1*a*, to secure the care in position during the flow of metal in the mould, the chaplets invariably gave trouble later on during the life

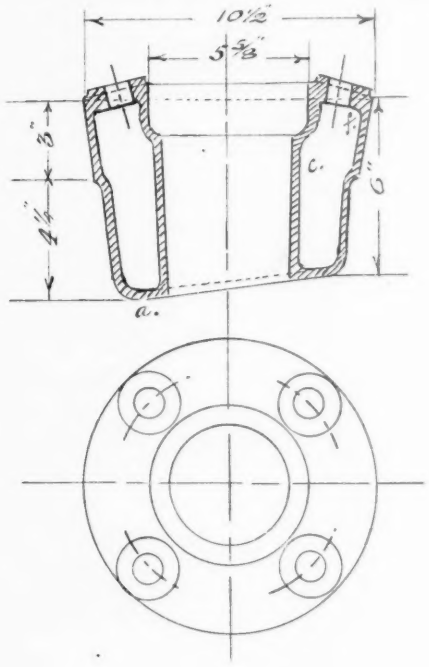


FIG 1.

of the casting. The method here described proved a success and no further trouble was experienced from this source. The wood pattern, Fig. 2, is made to leave its own core at *b* and mounted with core prints for the inlet and outlet water supply pipes as shown in Fig. 2, *1, 2, 3 and 4*.

Fig. 3 shows the process adopted to make the chamber core *c* (Fig. 1). The wood disc or flange *d* (Fig. 3), 12 in. in diameter and 1¾ in. thick, is turned on the lathe, and the joint or face *e* is made to correspond to that of the internal section of chamber at the end *f* (Fig. 1). A recess is also provided to take the centre dowell of plug *g* (Fig. 3). Four spaces are cut at equal centres on the outside of this ring as shown at *h*, V-shaped to locate the four loose pieces *j* (one of these only is shown). These are provided with semi-circular bosses or thickness pieces to correspond with those already mounted on to the flange; round holes are also cut in both parts to correspond with the core prints of

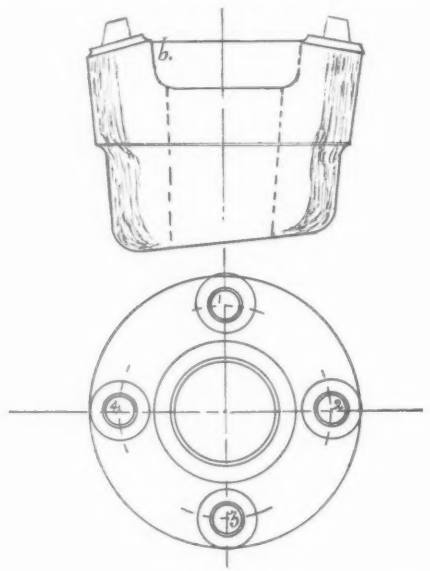


FIG 2.

1¼ in. diameter, already referred to, for the inlet and outlet pipes.

Centre plug *g* now takes its position on face *e*, located concentric with the outside diameter of the flange.

A cast-iron core-ring, shown in Fig. 4, is mounted with four ⅜-in. pipes screwed in on equal centres as shown; also it is screw-threaded at opposite ends, the purpose of which will be referred to later. Vent holes have already been drilled in these pipes; they are also wrapped around with hemp rope and clay-washed in the usual way. This ring is now fixed in position and sand is tucked around, using strickle K to finish on the outside. The chamber core is now

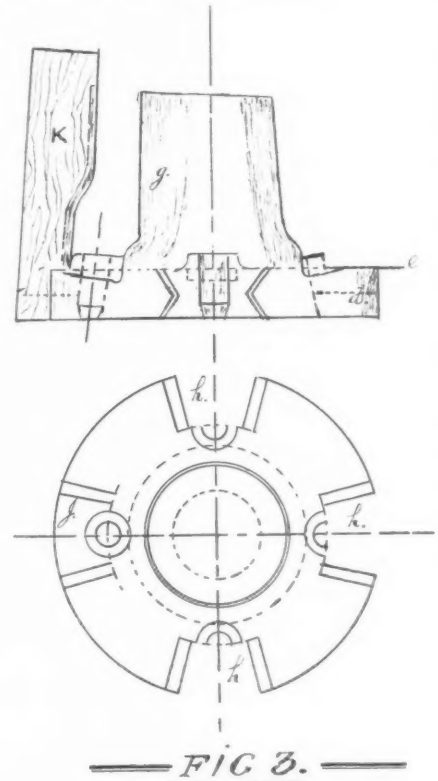


FIG 3.

ready for drying in the foundry store. Fig. 5 shows the mould assembled. In this view it is apparent how the core is held in position without

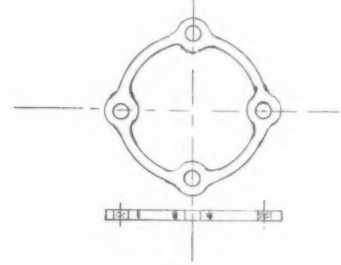

FIG 4.

the aid of the chaplets. The screwed end of the vent pipes protrude beyond the bottom face of box part 1, Fig. 5, and plate washers are

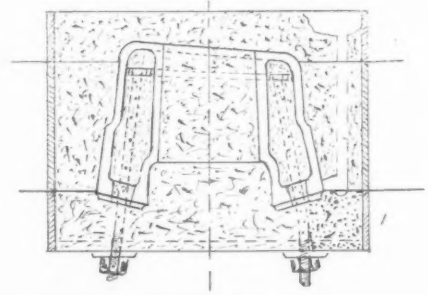

FIG 5.

laid in position over the threaded end of each pipe and the nuts screwed home as shown. The pipes only are recoverable, and the cast-iron ring has to be broken to be extricated.

## Deep-Joint Elimination.

(*Concluded from page* 251.)

illustrated by Figs. 6-10. In this case, a peculiar-looking, disjointed grey-iron ring, 3-ft. in diameter, is required to carry (among other things) deep brackets on either side, as at O, Fig. 6. Here again, if the pattern was made as a facsimile of the casting, it would be useless as a "vehicle of production." It might enter the foundry whole; but would return in pieces!

The curved guide, P, would certainly need to be cored out. Then something must be done to maintain the relative positions of the loose ends, Q. Unless these were firmly connected with each other the casting could not be expected to be like the pattern—even if the pattern was correct (a very problematical assumption under the circumstances). It would be, again, extremely difficult, if not impossible, to attach the side brackets, O, to the ring in such a manner as to enable them to be rammed up in the mould without distortion. And the brackets, O, would saddle the foundry with the handicap of deep joints. In order to get the top of the roller path clean, the job would mould upside down to that shown in the sketch.

The pattern, constructed as seen in Fig. 7, is rigid, reliable, easily moulded and durable. As in the previous example (Fig. 2), the job is built up on a plywood plate R. This, incidentally, is very convenient in the initial stage of the job, for setting out the positions of the brackets, and other members. The plywood is carried to the furthest extremity of the coreprints (seen at S), and forms for them an immovable support. Built up in this way, such coreprints defy both ramming and rapping.

It will be seen that the employment of a core at the wedge-shaped end of the ring, T, enables the plywood plate to be built into the coreprint. The curved-guide end of the ring, U, is similarly accommodated. Thus, the two loose ends of the ring are firmly connected. The cores V and W (of which the coreboxes are seen in Figs. 9 and 10, respectively) automatically stop out the plate, and produce the gap, Q, Fig. 6, as they are inserted in the mould. The other connections of the plywood to the ring, at X, are easily stopped off with the aid of a suitable segment.

The corebox for the coreprints Y is shown in Fig. 8, with the side removed for the purposes of illustration. It is seen to be upside down, as compared with the coreprints Y in Fig. 7. The centre rib Z will, no doubt, easily be related to that shown in Fig. 6.

# Foundry Education.

## PROFESSOR ANDREW'S SCHEME COMMENDED.

### Introduction.

When Prof. Andrew presented his Paper* to the Sheffield Branch of the Institute of British Foundrymen, it was excellently received, not only by the local members, but also by the President and Secretary of the Institute.

### Practical Training Still Essential.

Mr. W. T. Kitching, who presided, remarked that they had had an excellent description of the plant already installed at the university and the plans for inaugurating the course. There was no doubt that the day of the foundry foreman had not passed but the day of the foundry manager had arrived. The foundry manager of to-day must be able to manage the whole of the founding side of his business—that is to say, he must manage the pattern shop, the metal melting, the moulding, the casting and the fettling of the castings. He wished that he had had the opportunities as a student of absorbing the knowledge to be put before those who would no doubt take advantage of the scheme outlined by Prof. Andrew. Incidentally he would like to urge the youths to obtain their practical experience in a jobbing foundry and not to go into a mechanised foundry. In his opinion the mechanised foundry was destroying the practical man. It was impossible for the practical man to be dispensed with. They would always need the practical man. No amount of university, theoretical and metallurgical training would make the skilled practical moulder.

### The Need for Scientific Guidance.

Mr. Victor Stobie (President of the Institute) said that the lack of scientific training in founding might be likened to a ship that was beautifully built but without a rudder. A man without the scientific training would be buffetted about in the sea of experience. If he had a strong enough constitution and lived long enough he might get to his port of destination. If they gave that man his technical training it would provide the rudder for the ship and he could steer his way in a definite direction. Scientific training taught the fundamental laws of nature. A man who was scientifically-trained knew approximately in what direction it was safe to work and knew without any hit-and-miss—usually miss—experience what to avoid. The man of intellect without the scientific training was very much like a brilliant pianist whom one asked to play fine music and gave him a tin whistle to play upon. The curriculum that Prof. Andrew had put forward was really splendidly thought out. He had touched upon every point of founding with the exception of the point that Mr. Kitching had mentioned—manual practice. Of course the art—in so far as art existed in regard to founding—could not be taught by the University, but technical training was not going to spoil a man's art. On the contrary his art would be buttressed by a knowledge not possessed by the man without that training.

Speaking of the necessity of a knowledge of physics, Mr. Stobie said that when at times he had had to take a new man from the laboratory to take charge of a furnace he did not necessarily pick out the man with the greatest chemical knowledge by any means, nor necessarily the man who got the most accurate results; but the man who had shown in his work an appreciation of those things that were studied under the title of physics. In a foundry they found the need for a knowledge of physics to a greater extent probably than in any other department of work with which he had been associated. They had dynamics which were so necessary to enable a man to understand what was going to be the result of the way he guided his metal in the moulds, and moreover there was hydrostatic pressure. He had an experience some time ago of an excellent foreman who, through want of understanding of hydrostatic pressure built up a mound in the middle of a shape to make a 7-ton casting. The mould would have been perfect in every possible way but the man did not endow it with a sufficient strength to keep the steel within the mould because he did not know what hydrostatic pressure meant, yet was an excellent practical man. He would ask them to put this picture by the side of the picture that Mr. Kitching had presented. They needed the practical man but let him have the knowledge that was going to reinforce his practical experience. He did not think there was a centre that could compare with Sheffield for a course such as had been described. They had excellent laboratories available. Before other centres could possibly get as much plant as they had in Sheffield for the purpose, Sheffield would have gone a long way towards getting still more. The Institute of British Foundrymen was tremendously interested in the project. As many of them were aware, some two years or so ago the Institute decided that it was necessary to have tuition in founding throughout the country and it approached several dozen technical schools and colleges. It was a great thing to undertake because so many people up and down the country imagined that founding was merely playing about with sand but there was an enthusiastic response from all parts. They started off with several dozen technical schools and schools for higher education inaugurating foundry courses. One of these schools—Rutherford College, Newcastle—established itself on permanent lines with the help of a well-equipped foundry whereby young fellows were able to get the training they needed in a manner that would not be possible in a place under ordinary commercial conditions. That training, however, did not reach the type of man that Prof. Andrew's scheme aimed at helping. It taught more the operatives although a few foundry managers were taking the courses. Under the proposals outlined for Sheffield University they were going to train men for the ultimate conduct of the foundry so that they could raise the foundry to the status of any other department of industrial work. Industry to-day could not be based on lay imaginations as in the past. To-day they must base their reasoning on scientific facts. He thought they had listened to the description of the birth of a wonderful scheme.

### Well-Defined Objects.

Mr. Makemson (Secretary of the Institute) said that many schemes of foundry training in the past had been drafted on vague generalities and had tried to combine the training of a moulder and a metallurgist and various other things under one scheme. Professor Andrew's scheme did not fail in that respect; it had a very definite objective, namely, the training of the foundry technologist and the foundry administrator. As Mr. Stobie had pointed out, the technical training they believed the skilled moulder and foreman should have was receiving a considerable amount of attention, and the schemes that had been inaugurated were proceeding very successfully. Those schemes were sufficiently broad to enable an intelligent and persevering man to build on them a superstructure that would enable him to rise to quite the highest positions in the foundry industry. He hoped and believed that many of these higher positions would continue to be filled by men who had risen from the floor. At the same time they had to face the fact that intensive scientific training was required and would continue to be required in many branches of the industry, and the scheme to impart that training was certainly now due. He believed that such a scheme had been put before them by Professor Andrew. It had come at the right time, and, given reasonable encouragement, he was sure it was going to be exceedingly successful. Certainly no better place than Sheffield could have been chosen as the centre. In Sheffield they had a department of Metallurgy which was appreciated throughout the world. It had fine traditions, it was fully equipped and well staffed. The new scheme grafted on to such an existing department would start with the minimum amount of dislocation and the minimum amount of extra expense.

### The Engineering Aspect.

The highly-trained technician was not by any means a new departure in the foundry. There were many highly-trained men in the industry to-day, and they were increasing in number every year, but such men had come in with general metallurgical training or with general engineering training because they had not the opportunity in this country of taking a course that dealt specifically with the methods and peculiar problems to be met with in the foundry. The course that Professor Andrew had outlined would fill that gap and would provide general founding training as distinct from general metallurgical and engineering training. The syllabus of such a course would require a great deal of careful study, and he would suggest that in framing the curriculum and the syllabus the importance of some general engineering training ought not to be lost sight of. The question had been mentioned in the curriculum which the Professor had put forward. It was always a moot point as to whether foundry work was basically engineering or basically metallurgical. He would suggest it was both. The foundryman did encounter many metallurgical problems, but at the same time, in the main, he was producing articles for the engineering industry. Moreover, the foundry was becoming more and more rapidly mechanised and the management was making increasing use of machinery and modern appliances. On both those grounds, while certainly admitting the great importance of metallurgical training and training in physics, he suggested that some training in general engineering was quite as essential. There was one other point that he was not sure would be given its due need of attention. Sheffield's interests were primarily steel founding and heavy iron founding, but the men who took the University courses would naturally be distributed in foundries all over the country engaged in a variety of work. Admittedly, the general principles of founding were common to all branches, but he hoped that the examples drawn from, say, light iron founding, non-ferrous founding and particularly aluminium founding, would not be lost sight of. He believed that the foundry industry in the next few years was going to develop very largely on the side of quantity production of lighter castings and in the direction of non-ferrous castings, particularly in the aluminium alloys. The future of aluminium alloys was very great, and new vistas were continually being opened up as new applications were found.

The working out of the scheme described by Professor Andrew would present some interesting problems, and the Sheffield Branch of the Institute was to be congratulated upon having the honour of hearing the scheme explained for the first time. Moreover, Sheffield was to be congratulated upon having in its midst a university, a professor and a University Council so enterprising as to shoulder the scheme. It was up to them, as representatives of the industry, to give the scheme every possible encouragement. He was sure that this would be forthcoming.

### Forthcoming Support.

Mr. J. E. Hurst said he was sure that all foundrymen not only in this country but throughout the world would feel proud that at

* Foundry Trade Journal, March 16, 1933, page 189.

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last a British university had taken upon itself to recognise their industry. They in Sheffield he was sure would feel proud that their metallurgical professor, the metallurgical department and the Council of the University had been the first to recognise that need and put it into practical shape. The scheme having been launched and approved by the University Council all that remained to be done was for the trade to give it their utmost support. They in Sheffield could not expect to get support from the other parts of the country if they did not rally round their professor and their university themselves and give it all possible help. For his own part he had already offered Prof. Andrew his own personal assistance and anything he could do through the firms with which he was connected he would do. He took the opportunity of mentioning the matter a few days previously to the directors of Bradley & Foster, a firm with which he was associated, and they had authorised him to say that they were quite willing to give all the financial support they could and also to provide materials or plant that they might be able to supply. He was sure that some of the other firms with which he was connected would give equal support when the matter was put to them. It now only remained he thought for Prof. Andrew to tell them and tell the firms the exact nature of the support he wanted. He supposed that he would take steps in due course to arrange for this to be done. He was sure the scheme would get the support of Sheffield and, as the President had indicated, of the whole country, including the support of the Institute. He wished the scheme every success for it was a scheme that at last would give a *cachet* to foundrymen and place them on a level with the highest profession in the land.

### The Danger of Over-Specialisation.

Mr. A. Roebuck remarked that he agreed with all the previous speakers' comments and that Professor Andrew and his staff were to be complimented on getting as far as they had in the short time they had been studying the subject. He was just wondering to where it would lead. Perhaps it was a little apart from the subject, but the professor had put forward a scheme which specialised in making the administrator in founding. Now, still associated with metallurgy, were they going to develop on similar lines in other trades? Were they going to make a specialist in forging and smithy work? Were they going to make a specialist in machine-shop practice? Again let them reflect upon the vast amount of work and research in rolling-mill practice still associated with metallurgy. He just wondered if the professor had got so far as that, because if the firms engaged in these industries were to be asked to subscribe to all such schemes, then the financial aspect would be a serious matter. The point that arose in his mind was as to whether these other schemes would follow. He was not saying that they should not follow. In the syllabus put before them, Professor Andrew did not show anything in regard to the cleaning of the castings. With sand blasting, fettling with pneumatic contrivances and so on, it was of course appreciated that there was a definite relationship between the cleaning of the castings and the sand used in the moulding. He also wondered if anything in this scheme would queer the pitch of the lad that went to work in the foundry at 14 and applied himself to his industry with a view to making his way. At the age of 16 he would attend evening classes and at the age of 18 he would attend evening lectures at the university. A few days ago it was said in the House of Commons that the only way to train a sailor was to let him sail the high seas. In a like manner the only way to make a moulder was for him to work on the floor of a foundry. He was glad that Professor Andrew had stressed the necessity of getting the students put right up against the everyday working conditions of a foundry, where castings were made to a time and price, which was a far different proposition from producing satisfactory castings in the seclusion of a university.

### Intermural Help.

Mr. W. J. Rees (Sheffield University) said he thought that that meeting would be written as an historic one in regard to British foundrywork. The scheme that had been propounded was long overdue, and he wanted to assure Prof. Andrew that it would have the enthusiastic support of all departments of the University. In his own department, that dealt specifically with refractory material, they had had a great deal of contact with foundry practice, and he could assure Prof. Andrew that they would do everything they could to forward the scheme. Anything they could do to make the scheme a success they would do with very great enthusiasm. He was particularly glad that Prof. Andrew had stressed the importance of fundamental training. That was the real basis of any education scheme for the foundry industry. Without that fundamental knowledge it was not easily possible to build up a really sound foundry training. At the same time he would like to indicate that there was no need for such a scheme to crab in any way the prospects of the individual youth to whom Mr. Roebuck had referred. It provided him with a better opportunity than he had before. It gave him just the facilities that had been lacking to bring him to the topmost heights. He sincerely hoped that the scheme would receive the support it deserved from the foundry industry. The sum needed to carry out the scheme was really quite small for such an important national industry as the foundry industry. He was glad to have had the opportunity of saying how much he appreciated the scheme and wished it immediate success.

### A National Scheme.

Mr. M. Brown said he was sure that the scheme would be watched with great interest not only in Sheffield but all over the country. There was one point he would like to mention. The man who ran a mechanised foundry and who could not do his work properly with only a small percentage of wastage was not a foundryman. If they went into foundries that specialised in jobbing work and were really successful they almost always found one man who had made the shop by his long experience of foundry work. Such a man could look at a blue print or a pattern and sum it up rapidly. Through long years of experience he was able to tell at once very nearly where the troubles were likely to be and how to avoid them. It was a fact that conversation with these men revealed that they had great difficulty in explaining to anybody who had ordinary scientific training the whys and wherefores of his reasoning. All he could say was that his experience told him that such and such a thing should be done. He did not think the course would be complete unless there would be available somebody who had practical experience and who was capable of explaining it and putting his reasons before people who were interested. It would be interesting to know how the authorities would endeavour to overcome that very difficult point.

### Practice Wanted.

Mr. J. Roxburgh said he agreed with some of the other speakers when they declared that too much emphasis could not be laid on the practical side of foundry work. As had been stated, practical knowledge could only be gained by years of experience. He was a little afraid that the scheme outlined would produce a man well versed on the technical side but rather lacking on the practical side. There was no doubt that a little knowledge was dangerous. He could not conceive of such a man taking charge or being the administrator of a foundry. With all due respects to the technical man, he had found that when he came to apply his technical knowledge in the foundry he was up against insuperable difficulties, and had to consult the practical man almost every time. He felt that the product of Prof. Andrew's scheme would have to find a position in an advisory capacity to the executive manager of the foundry. Another point that had occurred to him concerned the expense of such a course. He felt that a lad who entered the foundry at 14 and served a number of years to obtain his practical knowledge would find he could not afford to go to a university to complete his training. He wondered whether scholarships would be available or some financial help for such a youth.

### AUTHOR'S REPLY.

Prof. Andrew said he wished to express his thanks for the kindly comments made on the proposed course. He thought he could go away feeling satisfied that it had had a very good reception. He wished to thank those people who had offered support in the inauguration of the scheme. In reply to the points that had been raised in the first place he wanted to make it clear that they were not out to substitute in any way the practical man. The practical man was essential in any foundry, and he would have the same chance as anyone else under the scheme. They were providing for him and would be only too willing to help anyone who wished to acquire a more scientific knowledge of the foundry. Mr. Roebuck had raised the question of too much specialisation and inquired whether consideration would be given to special courses in smithy work and forging. Well, for instance, no university could teach rolling practice. No university could afford a set of hot rolls and if it could it would need an excessively large staff to manage it. Metallurgy was such a broad subject that it was becoming necessary to specialise. It was impossible for one man to carry in his head a complete knowledge of ferrous and non-ferrous metallurgy in all its branches. The complete course would give him a good general knowledge in most branches, after that he must specialise in one way or another. Several speakers had insisted upon the importance of engineering knowledge. Such knowledge was essential in founding, but after all engineering entered into everything in life. At the same time the most important feature in the foundry, he thought, was in respect of the science of casting and the elimination of wasters and that depended largely on the condition of the moulding, the sands, cores, castings and the particular form and characteristics of the metals. The engineering aspect had advanced to an extraordinary degree but they were concerned primarily with the necessity of concentrating more on the metallurgical side. The question of aluminium alloys was, of course, an important one. People told him that the trouble with those alloys was in respect to getting a sound casting. That was entirely a metallurgical matter. He did not think they could teach the engineer much. Mr. Roebuck had mentioned the question of the cleaning of castings. He agreed that cleaning was a very important factor and they hoped to take up that side of foundry operations. In regard to the question that had been raised as to whether the scheme would restrict the foundry youth's outlook as he had said the youth going to the foundry would have every possible chance. He agreed with Mr. Roxburgh that it would be a good thing to initiate one or two scholarships. If the foundry youth found a matriculation course too formidable he could take an associateship course, and by gradually working up he would get to almost as high a level as the matriculated student. Scientific knowledge was largely a matter of applied common sense. Sufficient enthusiasm would carry people through everything. One speaker had referred to the question of mass production and had suggested that in a mechanised foundry everything went normally

(*Concluded on page* 256.)

# Modern Patternmaking.*

By W. Stafford.

### The Pattern Shop.

Patternmaking is a subject which should be more frequently discussed since the methods of constructing patterns influence vitally the cost of production, not only in the foundry and pattern shop, but also in the other engineering departments. It is therefore intended to outline how a pattern shop should be equipped and managed so as to produce the best results. Unfortunately, the pattern shop is generally considered as a department which very often fails to justify its expense because it does not produce a finished product. Of course, this discrimination is really an absurd estimate of the value of patternmaking, as similar criticism could be levelled against other departments of non-manual workers. It does not matter whether the labour is by hand or brain so long as it is considered that the effort is contributing its share to the creation and completion of the finished product.

### Equipment for a Modern Pattern Shop.

A pattern shop employing about 20 men and 12 apprentices will be taken as typical. The machines required to prevent time being lost by men kept waiting are as follow:—One circular saw; two band saws; one thicknessing machine; one "Wadkin" patternmaking machine; one lathe; one wet grindstone; two dimension saws; two sandpapering machines; one small pillar mill; one setting-out table with angle lines marked and three glue pots.

A pattern-room stores for material used in the workroom is a necessity, and, if possible, should be located in a place where there is no obstruction and which is handy for the workers.

No Paper on the patternmaking department would be complete without a reference to the "Wadkin" machine. There are two designs of the tool made, both bearing the same name, and each with its own special good points. The capabilities and resources of these machines are beyond dispute where there is sufficient work for them, and they amply repay their costs in reduced wages bill. The machine can be worked by a semi-skilled man, but the best results are obtained when it is operated by a skilled patternmaker, who understands more about the tupers and requirements of moulding, and is familiar with the correct sharpening of cutters. He would also be able to advise the workman as to how the work should be prepared for the machine. One of the great advantages of the tool is that half-patterns can be made and worked; if turned in the lathe these have to be built up in bold diameters, and, after finishing, half the pattern has to be scrapped. By being able to work half-patterns, time is saved in building and in the materials used. The machine does not actually finish the pattern; it cuts the various shapes required, and the workmen have to finish off by hand any ridges or marks left by the cutters, and then the pattern or core box is sandpapered to obtain the desired smoothness. The finishing part, as a rule, does not take much time.

The machine is also very useful for joinery work where the joiners and patternmakers are in the same department.

Another point in its favour is that core boxes can be built up for circular work, and are stronger than those that have to be turned in the lathe.

### Cost of Materials Used in the Pattern Shop.

There is no greater cause of complaint in the engineering works' offices than the heavy cost of patterns. The cost department appears to be under the impression that the charges put on the work by the patternmaking do not justify themselves; this is due in the main to their lack of knowledge of the practical side of the trade, as they fail to realise that the patternmakers' work is nearly all by hand and cannot be compared with a lathe or planing machine in the general engineering works, where a certain amount of work can be done in a day according to the speed of the machine. Another point they appear to overlook is the expensive materials used in the manufacture of patterns.

### Drawing for the Patternmaker.

In many works where short-time deliveries of orders are given the system prevails of sending to the pattern shop preliminary or temporary plans so that the patternmaker can start the order and save time while the plans are being finished. This, no doubt, is of considerable assistance to the progress of the orders providing that the drawings which are issued are not liable to radical alterations.

If good cheap patterns are to be made, which is all that is necessary, the best way to achieve this is to give the worker a good clear drawing with all the elevations, plans and sections of completed parts shown so that the ordinary patternmaker can read them. All machinery parts should be marked with the letter "F" or red-lined, and all internal cores with metal around them should be shown on the plan.

The arrangement for getting out the cores and allowing for the escape of gases can be arranged with the foundry manager whilst the drawings are in progress. It very often happens that when this is left to the discretion of the foreman concerned, he will put them in to suit himself in a place which is wrong.

Another point is the alteration of dimensions on existing drawings; these should be as conspicuous as possible so as to avoid any possible chance of error, and it is suggested that the general system of alteration be to ring the amended dimension in a distinctive colour other than red, as the use of this colour has been the cause of many patternmakers' troubles, due to the fact that it is recognised practice for machined surfaces to be outlined in red. Those who have to deal with altered plans will understand the importance of this question. The chief designer or his section leaders who are responsible for the drawings should pay a visit to the pattern shop when patterns are finished and inspect them. The time spent in doing so will not be lost in the majority of instances.

Another point which should not be left to the shop is that, where there are unequal thicknesses in the design of castings, the working of the thick parts from the thin parts by large hollows, brackets or root corners should be shown on the plans and be carefully thought out. By doing this the drawing office would help the foundry and save them from having cracks and breakages in the castings due to unequal constructions. Furthermore, the draughtsman is apt to make artistic designs rather than the more practical and simpler shapes, due solely to his lack of knowledge of patternmaking and foundry practice, and this has a decided tendency to increase the cost of the casting. Very often the weights of larger castings come out above the estimated weight, due to the mould being larger than the pattern, this being caused by loosening, finishing and swelling of the cores, and the draughtsman should bear this in mind when giving the estimated weights.

All alterations made on plans whilst the work is in progress should be notified to the foundry manager, so that care can be taken that none of them is overlooked.

Writing as a foreman patternmaker at a large works carrying out a great variety of work, the author is of the opinion that, if possible, a complete set of finished drawings should be sent into the shops with the orders for the work to be done. The job would then be done quicker and cheaper than is possible when the drawings are sent in as they are separately finished.

### Making Patterns to Help the Foundry to Produce Economically.

This is where the patternmaker's efforts are apt to be misunderstood. The writer holds the opinion that the pattern shop and foundry must work in harmony in order to produce the castings as quickly and cheaply as possible, and all efforts in this direction should be encouraged. Another helpful factor is to make as many patterns in halves at the moulding joint as possible. The designers might also help the foundry by giving large tapers when possible.

Then there is the question of large, deep core boxes, the sides and ends of which if bolted together and not screwed could be lifted away separately without damage. This saves much "finishing" by the coremaker and avoids turning over the core, which the writer deems to be a dangerous operation.

Another point in favour of making patterns when there are raised pieces on the top part, is that if these are all put on with dowel pins it enables the moulder to lift them with the top part of the mould and saves "a bad lift." It might be asked of all connected with the pattern shop if the time has not arrived when the great amount of cobbling done should be stopped. The temporary ways of making patterns and a great amount of stopping off and altering top and bottom parts of moulds, caused by using old patterns for new orders, gives the moulder a great amount of unnecessary labour. No one can expect a good casting at a reasonable price if it is left to the moulder to finish the patternmaker's work.

### The Patternmaker and His Training.

It is essential that the patternmaker should have a good knowledge of drawing-office and foundry practice. If he has not studied these advantages he is very often inclined to make unnecessarily expensive patterns; this is due to his uncertain knowledge of the possibilities of foundry methods. He may at times make his patterns to such a design that a costly method of moulding has to be adopted.

Wherever possible the patternmaker-apprentice should serve several months in a foundry before qualifying as a journeyman. Such a training will create ability to judge the best way to make a pattern. He will then have gained by experience and observation an intuition which will enable him to read quickly the draughtman's idea in all his plans so that he can reach a conclusion as to how to make his pattern and the best way of moulding and coring.

It would also be an advantage if the pattern-shop apprentices when serving this period in the foundry were given the opportunity of perusing the drawings whilst the moulding, etc., is in progress in order to visualise the finished casting. A like procedure could also be adopted in the case of the foundry apprentice and would no doubt be of considerable assistance to him.

The continuous changes the patternmaker meets with in his work should keep his mind alert for any difficulties that may arise, and if he is keen he will always find it interesting to him, and his first idea must be to make his pattern true to dimensions, the finishing to take second place.

### The Patternmaker and His Work.

In the pattern shop the designer has an opportunity to see his work complete before it is sent into the foundry. Although many views are shown there are several points where the

* A Paper read before the Junior Section of the Institute of British Foundrymen, Mr. R. A. Jones presiding.

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patternmaker must use his own judgment. Consideration must be given to the contraction of metals, camber and distortion which are allied to contraction. Core boxes for large cores are made smaller than the drawing to allow for the growth of the core during drying and handling. Therefore the pattermaker must have all these factors in mind when he commences the construction of patterns. For most large and medium-sized castings where there are a number of cores it is better for the patternmaker to draw out the job full size with the construction rule. This is a good method as it enables him to understand all the details of the plan. When the setting out is complete he will then discuss with the foreman the making of the pattern and its moulding.

Machine surfaces require very careful consideration, especially when both top and bottom surfaces are most important as a carriage, slides, etc., as the majority of these patterns are moulded face-down.

For large patterns it is best to build up frames half-lapped together so that the shrinkage of the timber does not affect the dimensions of the pattern. They keep their shape and are much lighter than when built in solid plates.

When patterns have top and bottom parts, they are best made in halves with dowel pins to secure them, and all loose pieces and bosses put on an inserted dowel piece so that they cannot get out of place.

When a number of loose pieces are required on a pattern they should be connected together in one piece, thereby saving much trouble in the foundry through being misplaced.

The designer could save trouble and annoyance in the pattern shop and foundry if he would try to have as few loose pieces and bosses as possible in his designs.

The most important part in the construction is the taper in patterns. The designer ignores it and so does the patternmaker if he is not controlled, and, if there is no proper taper allowed, the moulder in his efforts to draw it out of the mould damages both the mould and the pattern. The usual taper allowance is approximately $\frac{1}{8}$ in. to 1 ft. 6 in. Another important feature is that when a patternmaker is constructing his pattern for a green-sand mould, he must be very careful as the mould will swell and produce a larger casting. A green-sand moulded casting will always be found to be larger than a dry-sand moulded casting made from the same pattern.

### Blocking Out Patterns.

The decision to core out certain parts of a casting should only be taken after careful consideration with the foundry. A much better casting can be made if the pattern is constructed as near as possible to the desired shape. With ordinary care, under-cut portions of the mould can be formed most satisfactorily by loose pieces on the pattern, but very often internal coring makes this difficult. In some cases it is better to block out the pattern and core box, which may mean a cheaper casting, but to block out a pattern without thought is most absurd as it adds to the cost of patternmaking and core making and more time is required to locate them in the mould.

Again, it is impossible to avoid a joint and joint marks on the casting, which are more or less uneven and do not match. Then, again, there is the extra dressing of the castings. If the pattern is mounted on a plate, then there is some justification for so doing, especially for quantity production.

### DISCUSSION.

In proposing a vote of thanks, Mr. R. Yeoman said that the author was on the staff of a firm at present much to the fore on account of the Russian work they were doing.

After Mr. A. Flower had seconded, Mr. E. Longden said that the question of camber was a large one, which depended on size, depth and length of the required casting.

## High-Tensile Steel Castings.

Mr. J. Deschamps, of Messrs. Kryn & Lahy, Limited, of Letchworth, has for some time been experimenting on the reduction of non-metallic inclusions in steel. He finds that by taking suitable steps to obtain from his cupolas a metal fairly free from oxides, by desulphurising with soda ash the molten iron prior to converting, and finally killing with special deoxidisers to the exclusion of aluminium, the resultant steel is giving very much better tests. The test-piece (Fig. 1) was cold-bent in our presence and a corresponding tensile specimen from the same

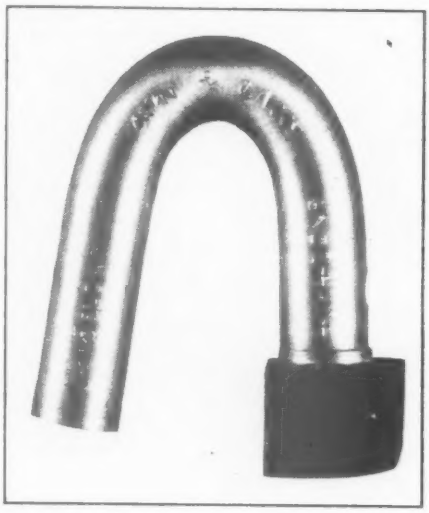

Fig. 1.—A 41.4-ton Tensile Cast-Steel Test-Piece Bent Cold.

cast gave 41.4 tons tensile and 19.5 per cent. elongation, the Brinell hardness in both cases being of the order of 183. The composition of the metal was: C, 0.32 per cent.; Si, 0.35; Mn, 0.8; S, 0.04, and P, 0.05 per cent.

A test-piece of such a composition, viz., with relatively low C and Mn contents, after having been subjected to standard annealing treatment, would be expected to give about 33 tons tensile and about 25 per cent. elongation.

The fact that a much higher tensile (41.4 tons) and a cold-bend test of 180 deg. without fracture were obtained is attributed by Mr. Deschamps to the absence of non-metallic inclusions.

## Insulating Refractories.

At the recent meeting of Committee C-8 of the American Society for Testing Materials on Refractories, held in Pittsburgh, it was definitely decided to begin work on the preparation of tests and specifications for high-temperature insulation and for insulating refractories.

The development of good refractory insulations is one of the most important achievements in the refractories field. There are now many new products which are reported to save operating costs, especially in intermittently-operated furnaces, by the use of insulation. In a good many cases these insulations are so refractory that they have been used to face the flame with or without a thin coating of refractory cement. The savings reported in many cases, for example, in heat-treating furnaces, have been phenomenal. Once the committee has developed standard test methods and specifications, some of the problems of the consumer in purchasing these materials will have been solved. Three proposed tests for use in specifications were submitted at the meeting. They cover (1) shrinkage under heat-treatment; (2) transverse strength; (3) crushing strength

## Foundry Education.

(*Concluded from page* 254.)

and there was no need for a metallurgist or anyone else to control matters because they went perfectly well. That was all very well, but he supposed that even in a mass-producing plant occasionally something went wrong and often it was difficult to find what had gone wrong, if one had only had practical training. The person who had a scientific as well as practical training stood a better chance of finding out the cause of the trouble than a man who had merely either the one or the other. In respect of what Mr. Roxburgh said about the need of practical experience he (the speaker) did not for one moment expect a man after taking a course of training to enter the foundry and manage it at once. He would have to go into the shops, but there was no reason why a man who had had scientific training should not have practical training afterwards and become what he might term a super-foundryman. Practical training and contact with the practical man were essential to the student. The effect of one or two scientific men in a foundry was to enthuse everyone concerned. One would try to learn something from the other. Two men working side by side and putting their heads together could generally improve things without any antagonism.

In regard to the question that had been asked as to the funds required to put the matter in ordinary clear figures, he thought they would require as a beginning an income of about £2,000 a year. Of course, if they had £3,000, they could develop more extensively, but they could start the scheme with an income of £2,000 a year. When they remembered that there were more than 3,000 iron foundries in the country, he did not think that that was asking for a great deal, for he was sure that the industry was going to benefit by it. The university was out to help the industry. The university was not a profit-making concern. All the staff were extremely interested in the scheme and were a band of enthusiasts. They were only too delighted to do anything they could and would gladly assist any works or any member of any works in problems in which they might be able to help. In regard to works problems, they did not wish to compete with any industrial research association. At the same time, they desired to state their willingness to help any foundry in any of its troubles. If any foundry found itself up against any problem, his staff and he would gladly do all they could toward eradicating the trouble. He again wished to express his thanks for the reception given to the scheme.

Mr. T. R. Walker proposed a vote of thanks to Prof. Andrew for his Paper. He said that it was his unfortunate duty at times to interview youths of 16 or 17, most of whom had matriculated or taken the school certificate with a view to their entering the foundry. When those youths were asked what they had read, it was found that they had covered an enormous syllabus, but when they were asked about something not exactly set out in the text-books, they failed immediately to satisfy the questions.

Mr. A. Whiteley seconded, and said that Prof. Andrew's Paper had made him wish that he was a young foundryman starting in life. He would very much have liked to have had the opportunity of taking advantage of the courses.

Mr. Stobie supported the vote of thanks, and said he had been greatly struck by the way the professor had advocated the scheme. He intended to bring a motion forward at the next meeting of the Council of the Institute to consider the scheme.

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The London Midland & Scottish Railway Company have placed an order for four Diesel direct-drive locomotives with the Hunslet Engine Company, Limited, of Leeds.

# The Sand Question in Regard to Light-Casting Production.*

By Frank Hudson.

Looking back over the past few years, it is very gratifying to see that a greater interest is being taken by the foundrymen regarding the study of sand. Not only are more Papers and articles being published, but we see this interest very much in evidence by the disappearance of the tumble-down pug mill and shovel and their replacement by efficient sand-preparation plants in the more progressive foundries. British interest, however, is not yet so keen as shown by other countries, notably the United States. Previous to 1921, comparatively little thought had been given to sand problems, and it was left to the American Foundrymen's Association to initiate organised research into the matter in this year.

To-day this Association has an enormous amount of information at its disposal in regard to sand problems and holds premier position for work in this field. Its findings would fill three full-sized text-books, and they embrace every field of casting production. Furthermore, approximately $20,000 was contributed by various sources to the American Foundrymen's Association to ensure success of this project.

To-day the Institute of British Foundrymen are in a position similar to the American Foundrymen's Association twelve years ago.

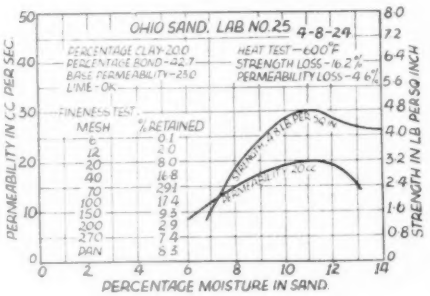


Fig. 1.

Many are no doubt familiar with the very important step taken by the Institute of British Foundrymen recently in forming Technical Sub-Committees to study the various phases of foundry work, and the author has the privilege of being a member of the Sand and Refractories Sub-Committee. In the very near future this committee hopes to publish a Paper giving its recommendations for green-sand testing equipment, and through the courtesy of Messrs. Glenfield & Kennedy arrangements were made to effect a comparison of existing testing equipment in their foundries. Without disclosing confidential information and the general opinion of the Technical Sub-Committee the author's tests have led to the formation of personal opinions relative to the most suitable testing equipment, and it is proposed to comment on these now.

It will be appreciated that for the industry to obtain full benefit from any work on foundry sands the various investigators must work to common standards so far as their test results are concerned. In the author's opinion the following points should be carefully considered when considering suitable routine control testing methods:

(1) The apparatus must be as simple and robust as possible and capable of being used by any intelligent foundry operator; and (2) the results obtained should be capable of international comparison.

* Extracted from a Paper read before the Falkirk Section of the Institute of British Foundrymen, Mr. T. Shanks presiding.

Dr. Skerl, of the British Cast Iron Research Association, raised this latter point at the London International Foundrymen's Congress held in 1929. Commenting on the Dutch Exchange Paper, "The Problem of Foundry Moulding Sand," he pointed out that the author of the Paper had taken test methods from various sources, methods which in the countries of their origin had not received the unqualified support of the Committee dealing with the question of sand testing, and he asked if some attempt could be made to form an international committee to discuss this problem, as until sand-testing methods were internationalised, it would not be possible to make the fullest use of published results.

Obviously, in view of the American Foundrymen's Association having done by far and away the most work on foundry sands, the quickest way to ensure internationalisation of tests is by the adoption of apparatus that will effect comparative results with American standards.

Past work done by British investigators has been individual, and the need for standard test methods has not been of great importance. Without belittling the very valuable work done by these workers, one cannot help but notice how much more valuable would have been this work, and how much more rapid the progress, if co-ordination had been possible. To obtain co-ordination, the use of standardised testing methods is essential, and only by co-ordination will a more extended interest in the problems of foundry sands be developed by the foundry trade at large.

The first three fundamental points relative to the sand question in regard to light-casting production, and which incidentally should be the first aim of every founder interested in a study of foundry sands, can be stated as control of moisture, strength and permeability. Furthermore, as the majority of light castings are made in green sand, the remarks in regard to the control and the effect of control of these three points will hinge principally on this form of moulding, although comment will be made on other facts dealing with the dry-sand side, particularly applicable to oil-sand practice.

### Moisture in Moulding Sand.

Every sand has a certain moisture content that will give the best results so far as bond strength and permeability are concerned, and the first step in foundry-sand control should be directed towards the tempering of the sand in such a way as to bring out these maximum or optimum properties. Invariably this has to be found by the simple experiment of tempering the sand at varying moisture percentages and testing at each of these tempers. Fig. 1 shows a typical data sheet of an American sand used for light-casting production by the United States Radiator Corporation given by Dietert.[1]

It will be observed that in this sand the maximum green strength and permeability are developed with 11 per cent. moisture, although this is not always the case for every sand. Furthermore, by plotting the test results in graphical form one gets immediately a good idea of possible working latitudes, so far as the effect of moisture is concerned. The shape of the curve gives a good index regarding the ease with which any particular sand can be handled in the foundry, for, obviously, as the curve tends to straighten out in the horizontal position, then the less is it affected by moisture and the less need for control. In the study of new sands by this method nothing must be taken for granted. If a sand requires 11 per cent. of moisture to bring out its best properties, it does not follow that a foundry-sand mixture made from this sand will require the same amount of moisture. The other constituents in the mixture affect the percentage of moisture considerably, and in this respect it may be of interest to mention that the amount of usage given to any sand has an important bearing on this point. After sands have been in use in the foundry for a certain time the amount of water required for tempering is only slightly affected in some sands, whilst in others a decrease of 4 to 5 per cent. is not unusual.

In Fig. 2 is shown the effect of moisture on another sand, and in this case test results giving the dried strength and permeability are included. It is not sufficiently appreciated what an important part the dried strength of even green sand plays in the economic production of iron castings. One can have a sand possessing a strong green bond, yet the dried strength may be low, and if a sand of this nature is used, the first inrush of metal dries certain portions of the mould and the sand is washed away, due to its lack of cohesion, to form defects in the casting. This is a prolific source of that defect known as a "sand-hole."

Reverting to Fig. 2, it will be observed that the amount of moisture required to develop the maximum dry-sand strength is considerably greater than is required for developing maximum green bond. Generally speaking, this is a characteristic of most sands and one of the main reasons why more moisture is used in those sands employed for dry-sand moulding. Here

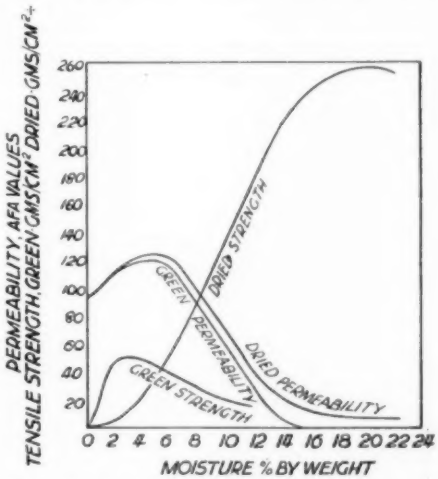


Fig. 2.—Influence of Moisture Content on the Physical Properties of Sand.

again, however, the best dry-sand strength figures must be found by experiment, and the result intelligently interpreted in order to produce a suitable sand mixture that can be used in the foundry. For example, in Fig. 2, about 20 per cent. of moisture is required to develop maximum dried strength. Remember that the sand must be capable of being rammed and firms are not, in this country at any rate, making moulds from cement. Accordingly, so far as dried strength of a sand is concerned, the moisture will be limited to the practice.

An important part is played by moisture on the alterations a sand must undergo during mixing. If a sand is milled too dry the tendency will be for a grinding action to take place more readily than if it contains the correct amount of moisture. If it is milled too wet the bond will not be uniformly distributed and will tend to segregate. Generally speaking, it is most advantageous to mill the sand when the moisture content is slightly less than the optimum one. Here again there is another indication of the value of sand-control tests.

A further example of the effect of moisture on a moulding sand was given in an excellent Paper by Reichert and Woolley,[2] and the tests

were conducted in the works of the Singer Manufacturing Company, U.S.A., producers of light castings. The conclusions reached from the investigations showed that the moisture content and grain size of the moulding sand used were the main factors in influencing the surface quality of a casting, and in selecting a sand for this purpose the two factors mentioned above must be considered in conjunction with the physical properties required by the particular mould. A moisture content of 5½ per cent. produced the best surface finish.

A moulding sand of 3E grain fineness on the American Foundrymen's Association's Classification is made up from a sand containing approximately 10 to 15 per cent. of clay substance and having the size of its grains approximating to the coarser red sands of this country, such as Mansfield, about 61 per cent. passing through a 100-mesh sieve, and typical of a sand one would expect to find extensively used for light work. Furthermore, it is interesting to point out that the amount of moisture required to produce the best finish in the example referred to is coincident with that required to produce optimum green-bond strength and permeability. This, however, may not apply to all sands. It should also be pointed out that the authors of this work studied the effect of other variables such as mould hardness, coal-dust additions, increase in clay content, method of ramming the mould and pouring temperature and fluidity of the metal, and whilst it is recognised that these have a definite effect on the surface finish produced they are not nearly so important as the grain size and moisture content of the moulding sand used. This point is not so fully appreciated as it ought to be. A final point in regard to the effect of moisture on sands is in regard to the working of the sand in the actual moulding operation. Too much moisture leads to a decrease in mould hardness, and the mould surface will not support as much load as it would if correctly tempered. Conversely, a harder mould surface is produced by too little moisture, although this condition is not so fatal as moulds having a softer surface. The variation of moisture and its effect on the mould surface is naturally most pronounced in foundries which use

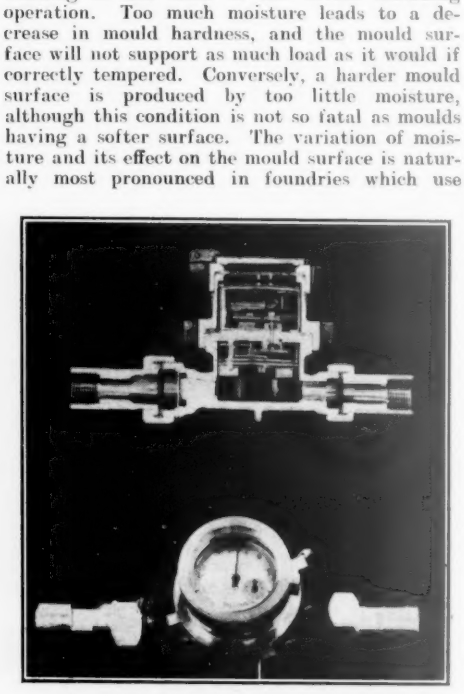

Fig. 3.—Type of Water Meter used for Sand-Testing.

machines extensively, as this tends to standardise ramming practice, and the effect of moisture variations can consequently be more readily noticed.

These examples of the effect moisture has on the properties of a moulding sand provide sufficient evidence for the need of moisture control if one desires to produce the best castings with least defective work. Moisture control plays no little part in the elimination of such defects as overweight castings, swells, strains, poor finish, wash from runner, blowholes and scabs.

### Moisture Control.

A system which has proved very successful in the Glenfield foundries is the use of meters on the sand-preparation plant actually to measure the requisite amount of water added to each batch of sand, in conjunction with the routine

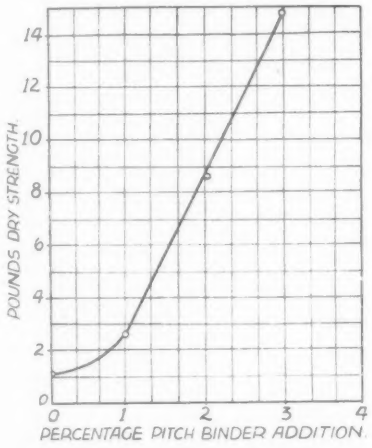


Fig. 4.—Influence of Pitch Additions on Dry Strength of Sand.

shop tests conducted by means of the "Speedy" moisture-tester. Fig. 3 illustrates the type of water meter used by the author. It is a "Glenfield" rotary type meter which can be connected in the pipe main as shown, supplied for wall mounting, or in a portable form for wetting-down sand heaps in the foundry.

The "Speedy" moisture-tester is used for the routine shop tests. This instrument has been a very great help to us in the problem of moisture control and gives rapid and accurate results. A point is made of having the instrument checked weekly in the laboratory against the usual standard method of moisture determination and of issuing a correction graph for inaccuracies that may arise. This correction may not be required in all cases, as the instrument is remarkably robust. In fact, during the six months this instrument has been in operation only one correction has had to be made, and this was the direct result of a blow or knock received whilst in service, which caused the pointer on the gauge to be offset. The best sands for foundry practice are those which develop their maximum green-bond strength and permeability with the same amount of tempering water. The smaller the variation of these two properties over a range of tempering limits, the better do sands become and they will stand the abuse that quantity production entails. On the other hand there are some sands which show rapid changes in green-bond strength and permeability, with small variations in moisture content, and these require careful watching to give satisfactory results.

### Green-Bond Strength.

This factor is dependent upon the amount of clay or other bonding material present, the kind of bonding material, the texture of the sand and the relations existing between the sand grains and the bond material. A good deal of investigation work has been conducted and published, and it is not intended to review these points as they are fairly well known. Flowability, however, is apt to be overlooked in considering the green-bond strength of sands. This is the ability of the sand to flow under ramming energy to form a smooth, uniform surface against the pattern. Obviously, if a sand possesses too much green bond the "flowability" will be low, and if this sand is used on certain types of moulding machines, particularly of the "jarring" type, one is apt to obtain soft patches or voids. Dietert[3] states that "Assuming that the average moulding sand has a compression strength of 6 lbs. per sq. in., it is worked in a range where variation of green-bond strength changes the mould hardness for a given standardised ramming, and these changes are of such magnitude that it is desirable to control the strength at an exact figure." So far as the control of green-bond strength is concerned, the compression test is by far the most satisfactory, and one can use either of the "Standard Methods" suggested by the American Foundrymen's Association or the British Cast Iron Research Association. Personally the author prefers the American method, as he considers uniform ramming of the test-specimen is more simply obtained and there is less likelihood of errors arising. The form of practice usually obtained by the use of the American method differs considerably from that obtained by the B.C.I.R.A. method. The appearance of the test-piece after fracture from this latter method has more an indication of shear measurement than of compression.

The importance of dried strength for green-sand work as well as green bond strength has already been stressed. It will be appreciated that every green-sand mould made is a skin-dried mould before it is completely poured, and it is suggested that many of the green sands used in this country could profitably receive attention on this point. A green sand giving a high green-bond strength may not necessarily have a satisfactory dried strength, and whilst an excessively high dried strength is objectionable, there certainly exists a limiting dry-strength factor for satisfactory practice just the same as a certain green-bond strength figure is required. That this is of importance has been amply demonstrated by Mr. Hird in his recent Paper "Black Sand."[4]

In this excellent work it is shown that apparently there is no need for the addition of new sand to keep up the strength of the black sand, providing about 2½ per cent. of coal dust is milled into the sand, and the theory is advanced that by the addition of this coal dust the grains of sand acquire a rough carbon coating by the casting process which acts as a mechanical bond in replacing the clay bond which has been

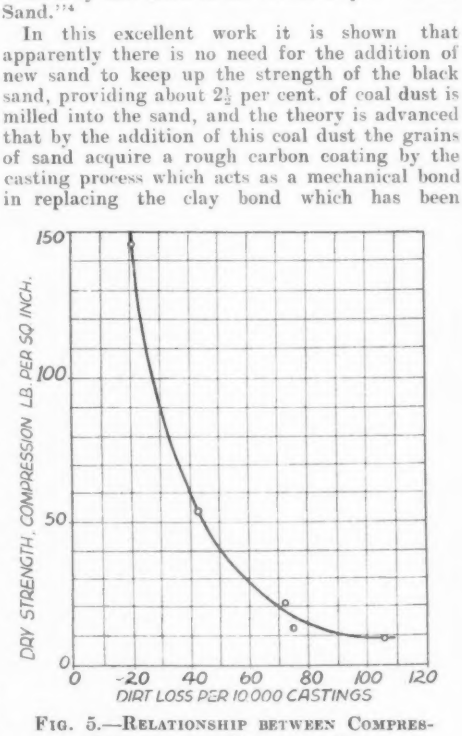


Fig. 5.—Relationship between Compression Strength and Defective Castings.

destroyed, combined with the dried strength imparted by the changing of the coal dust into coked tarry matter due to the action of the molten metal in contact with the sand.

Interesting confirmatory evidence of Mr. Hird's valuable work is shown in Fig. 4, which illustrates the effect of pitch additions on the dried strength of green sand. Industry is indebted for this evidence to H. G. Dietert and H. W. Wakefield[5] on tests conducted at the plant

of the United States Radiator Corporation. These authors consider that the addition of pitch is about twice as powerful in its action on dried strength as coal dust, and its addition is very beneficial in reducing casting loss providing the original sand is low in dry strength. In fact, they give a definite example of an instance in which the casting loss was reduced by 55 per cent. by the use of pitch to increase the dry-sand strength from 1.5 to 5.7 lbs. The same authors show a comparison of the casting loss at

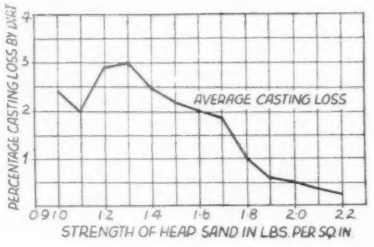


Fig. 6.

the various plants of the United States Radiator Corporation against the dry strength of the green sand used. This comparison is represented graphically in Fig. 5, from which it will be observed that the plant using a moulding sand with 7 lbs. dry strength had a dirt loss of 108 castings per 10,000 castings, as against another plant losing only 44 castings per 10,000 castings when a dried strength of 50 lbs. was used.

The question of dried strength will undoubtedly play a very valuable part in the foundry industry of the future, and should be of particular interest to the light-casting industry. Before leaving the question of bond, attention is drawn to Fig. 6. This is again taken from Dietert's work,[1] and correlates the percentage casting loss experienced on radiators, *versus* green bond as indicated by the compressive strength in lbs. per sq. in.

It will be observed that the casting loss due to dirt is greatly decreased by an increase in the green-bond strength of the heap sand used. It also shows that the strength of the sand should be above 2.2 lbs. to ensure a low percentage casting loss due to dirt. The dried strength can be tested by compression on the apparatus previously outlined by the substitution of a heavier spring balance or it can be tested by the transverse test. At the Glenfield works this latter method is used, and Fig. 7 shows the moulding box used to obtain uniform and comparative ramming of the test specimen, whilst in Fig. 8 is shown the actual transverse testing machine.

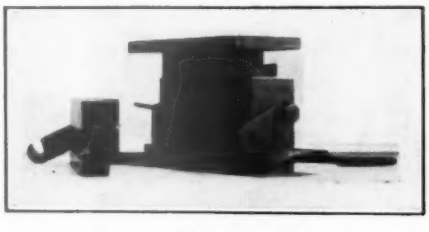

Fig. 7.—Type of Moulding Box used for preparing Samples of Sand for Testing.

**Permeability.**

There are three factors which affect the question of permeability other than the percentage of moisture, and these are (1) natural permeability as shown by any particular sand in the cold state; (2) the permeability of that sand in the hot state representative of conditions during the casting of the mould, and (3) the amount of gas generated by the casting operation, the safe removal of which is determined by a combination of both the previous factors. There is, of course, the question of sand compaction imparted by the ramming operation, but as the effect of this is fairly well known it is intended to omit this point.

In regard to the control of natural or cold permeability, the most practical method for testing purposes is that developed by C. P. Karr of the United States Bureau of Standards, subsequent modifications of this apparatus being adopted by the American Foundrymen's Association and latterly by Mr. Richardson of the Institute of British Foundrymen. In testing the permeability of foundry sands it is very important that the apparatus used is capable of giving the index of permeability to a unit basis, whereby different sands can be definitely compared. Such a basis requires the adoption of a permeability number based upon the time a definite quantity of some gas at a certain pressure takes to flow through a standard rammed section of sand of known cubic capacity. Test methods which give the permeability figure as a measure only of time or pressure are not satisfactory, if one desires a full measure of comparison with the bulk of reference work available.

In the original A.F.A. permeability apparatus the standard compression test core is employed, drop rammed.

The method of conducting the test consists of the time required to pass 2,000 c.c. of air through the test specimen, noting the time and pressure in so doing. The permeability is then expressed as a number calculated from a simple formula. Latterly the apparatus can be obtained in a modified form, having a direct-reading scale, the use of which eliminates any

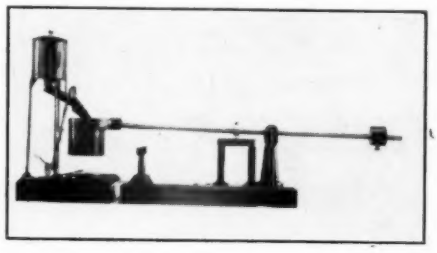

Fig. 8.—Transverse Sand-Testing Machine.

need of calculation. By the employment of the formula the results obtained from apparatus of this type are comparable and the apparatus can be termed direct apparatus. Apparatus which requires calibration or which gives a permeability reading from the measurement of one variable alone are classed as indirect apparatus. The benefit of using direct apparatus is that the permeability values found are the actual volume of air or gas that the sand will pass, therefore a sand with 50 permeability is twice as open as a 25-permeability sand. With the indirect apparatus this assumption does not necessarily apply.

An interesting modification of the A.F.A. type of apparatus has recently been devised by Richardson. Personally, the author is interested in this type at the present time, as, whilst originally the apparatus was put forward as an indirect type and the measurement of permeability was indicated by the pressure of air alone, it should be feasible to obtain the direct apparatus reading by consideration of both the volume and pressure of the air passing. Using permeability apparatus of this nature very valuable work is possible so far as sand control in the foundry is concerned.

Fig. 9 shows the reduction of casting loss in the boiler section of the United States Radiator Corporation by increasing the permeability of the heap sand used. It is extracted from Dietert's Paper[1], in which he states that not only was the casting loss reduced, but the finish of the castings was improved and less new sand used as well as other certain benefits.

The remarks up to this point have dealt with the permeability of sand in the natural or cold state. Unfortunately this property alters considerably when the sand is heated to, say, 1,000 deg. C. as would occur when any mould is cast. A recent research[2] by Saunders on the effect of heat on the permeability of natural moulding sands shows that the permeability is reduced considerably irrespective of the class of sand or the location from which it comes. On heating sand it was found that there was considerable variation in permeability between 100 to 200 deg. C. due to the steam formed from the moisture in the sand. Above 200 deg. C. the permeability steadily decreases, due to the expansion of the sand grains, until a temperature of about 600 deg. C. is reached. Between 600 and 1,000 deg. C. there is little change in permeability, because there is no appreciable expansion of the sand grains to cut down the flow of air.

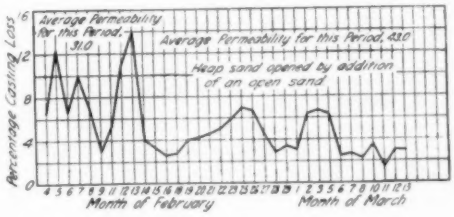
Average Permeability for this Period, 310
Average Permeability for this Period, 430
Heap sand opened by addition of an open sand
Percentage Casting Loss
Month of February
Month of March

Fig. 9.—Reduction of Boiler-Casting Loss by increasing the Permeability of the Floor Sand.

In Fig. 10 is shown some of the results of Saunders work, and it is interesting to note the remarkable decrease in permeability due to heat. Whilst this particular illustration deals with core sands, the results shown are typically representative of the natural green sands, with the exception that all the green sands give the characteristic "hump" as shown in the middle curve in this graph, due to the evolution of steam. In conjunction with this decrease in permeability, due to heat, it must also be remembered that most sands evolve considerable quantities of gas, other than steam, when heated, and from personal work in this connection it has been found that the majority of the natural sands in use in this country evolve between 1 to 20 cub. ft. of gas from 1 cub. ft. of their dried volume. When carbonaceous matter is added, such as is common practice for green-sand work, the amount of gas involved is really considerable,

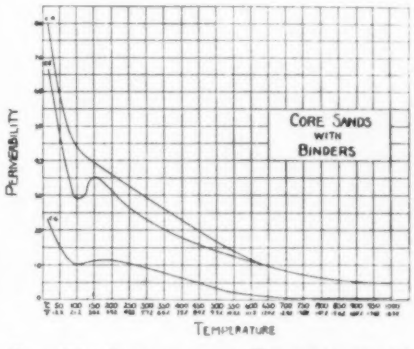


Fig. 10.—Influence of Temperature on Permeability of Core Sands.

amounting to as much as 165 times the volume of sand used, and this it should be noted is excluding steam.

Fig. 11 shows an apparatus used for the determination of gas evolved from sands by Riebold and Prinz for use under more practical conditions.

Up to now the Paper has dealt with the requirements for giving practical control, and it is by no means necessary for a firm to have a

laboratory in order to obtain the obvious advantages of sand control. So far as this problem is concerned in regard to the light casting industry, a very fine example has been set by American concerns, and it is worth while noting that the greater percentage of work done on sand and its control in that country is by firms associated with the light casting industry.

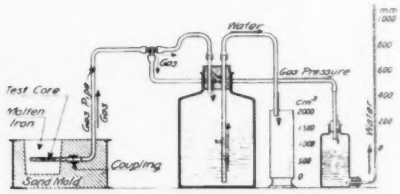


Fig. 11.—Apparatus for Testing Gas Evolution from Cores.

Fig. 12 is a further record given by Dietert showing the physical properties of the sand used for boilers, over a period, by the United States Radiator Corporation. It is interesting to note the obvious relation between green bond strength and permeability. In this case, as the strength of the sand increases the permeability decreases. In Table I is given some of the sand-test values used in America for light casting production known to give good results, whilst in Fig. 13

Table I.

| Kind of casting and type of ramming. | Per cent. moisture. | Compression strength. Lbs. per sq. in. | | A.F.A. permeability No. |
|---|---|---|---|---|
| | | Green. | Dry. | |
| Bath tubs (sand-slinger) .. .. | 5.0 to 6.0 | 3.6 | 46 | 70 |
| Boiler sections (jolt) | 6.0 to 7.0 | 4.3 | 40 | 80 |
| Boiler sections (sandslinger) .. | 5.5 to 6.5 | 4.2 | 40 | 80 |
| Radiators (hand rammed) .. | 6.0 to 7.0 | 3.5 | 52 | 35 |
| Radiators (machine) | 6.0 to 7.0 | 4.1 | 52 | 35 |
| 8 lbs. plate.. .. | 8.0 to 9.0 | 3.8 | 33 | 15 |
| Stove plate (squeeze) | 8.5 to 9.0 | 4.4 | 19 | 19 |

there is the answer to the question—Is sand control worth while? This record again is by the courtesy of the United States Radiator Corporation.

Some of the desirable features of sand control given to the foundryman can be stated as follows:—(1) The condition of the sand can be adjusted before reaching the point where bad

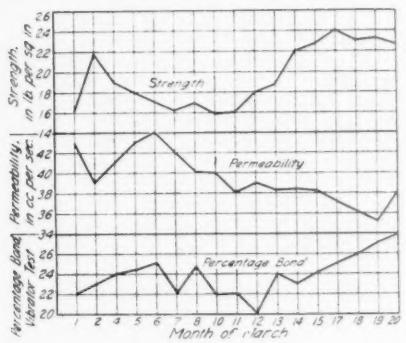


Fig. 12.—Physical Properties of Sand from C.I. Boiler Floor.

castings result; (2) removes moulder's alibi that the sand is responsible for defective castings due to improper moulding methods; (3) saves time, effort and material in investigations as to the cause of certain defects in castings, eliminating the factor of sand and enabling immediate concentration on other factors that might have a bearing; (4) makes possible a record of physical characteristics of sand that have produced best results on certain jobs and makes duplication of these characteristics possible; (5) provides a guide useful in the blending or mixing of sand best adapted for certain work; (6) aids in conservation of sand by preventing new sand additions until physical characteristics are such as to make this advisable; and (7) sand tests provide ready means of obtaining uniformity.

The author has found fineness tests, commonly known as sieve tests, very valuable if conducted in a suitable manner, and the methods adopted at Messrs. Glenfield & Kennedy consist of first shaking up a sample of the sand under test in distilled water containing a little alkali such as caustic soda. The sand and alkali solution is put into bottles and placed in a machine as shown in Fig. 14 and shaken by rotation until all the clay has been washed from the sand grains. The purpose of the alkali is to ensure the clay being held in solution and prevent it settling out. After a certain standard period of time the sample is removed from the machine and the suspended solution of clay and water removed by syphon leaving the base sand-grains in the bottle. The difference in weight before and after washing gives one a good index of the percentage of clay and silt present in the sand. After washing the sand is sieved on B.E.S.A. standard sieves and divided up into its various grain sizes. To facilitate sieving, a shaking machine controlled by a time switch is employed. Considerable value is placed on this test, as it gives an index of the percentage of "fines" in the sand, coming from the sand-preparation plant, and provides a check on clay content in

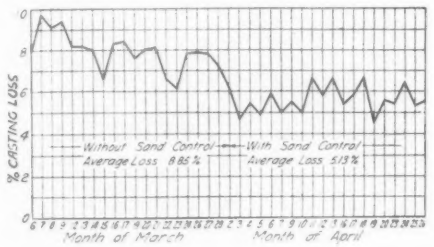


Fig. 13.—Reduction of Loss in Radiator Section through Sand Control.

new sand consignments. In the past, one of the objections to the use of the sieve test was the lack of standard mesh sizes. This has now been overcome, thanks to the work of the British Engineering Standards Association, and a specification is now in existence covering the requirements of test sieves.

According to Reichert & Woolley, the effect of grain size on casting finish is that the finer the sand, the finer the surface finish produced on the casting, providing the moisture content is correct. This is an obvious conclusion accepted by most foundrymen, but it should be understood that by a sand of fine texture is meant "a sand containing grains of uniform size and of sufficient fineness to produce the required smoothness on the surface of the castings," as this is different from the practice sometimes adopted of adding a very fine sand to a coarser one in the hope of obtaining satisfactory finish. This latter method is not to be recommended. Another advantage of sieve testing is in connection with core sands.

In this connection it is interesting to note that the Glenfield works are situated by the side of a little river which sometimes floods very seriously. The last time it caused concern it tried to make up for its bad behaviour by leaving behind 100 tons of sand, which appeared ideal for use in oil-sand cores. Accordingly a sample was sent to the laboratory for examination, and the results are shown in Table II. It will be observed that the deposited sand had a nice uniform grain size, but it contained about 4 per cent. clay and silt, which spoilt any chance of its employment as a core sand due to the extra quality of core oil required to obtain cores of satisfactory strength.

Another laboratory test of interest and recent development deals with the microscopical ex-

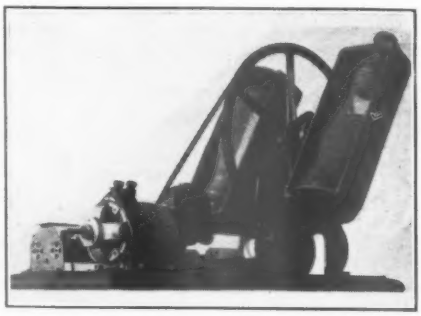

Fig. 14.—Machine for Shaking Sand Samples with Alkaline Water.

amination of sands. If a sand be examined under the ordinary microscope it is extremely difficult to tell which is clay and which is the quartz composing the base sand grain. Dierker,[7]

Table II.—*Effect of Sand on Core Oil Economy.*

| | Irvine sea sand. | Deposited sand. |
|---|---|---|
| Sieve test— | | |
| Per cent. passing mesh 20 .. | 98.6 | 97.6 |
| " " " 30 .. | 96.3 | 88.3 |
| " " " 40 .. | 91.5 | 70.8 |
| " " " 60 .. | 45.6 | 18.0 |
| " " " 80 .. | 12.4 | 6.4 |
| " " " 90 .. | 6.1 | 4.4 |
| " " " 100 .. | 2.9 | 3.2 |
| " " " 120 .. | 1.6 | 2.5 |
| Per cent clay and silt .. .. | 0.8 | 4.34 |
| Transverse strength in lbs. per sq. in., of cores containing 3 per cent. by weight of core oil baked at 300 deg. F. for 1½ hrs. | 91.4 | 22.7 |

however, demonstrates that if the sand is immersed in an oil whose index of refraction (1.55 such as cedarwood oil) approximates that of quartz, the quartz will tend to be invisible, and the clay will stand out in relief, as will be seen

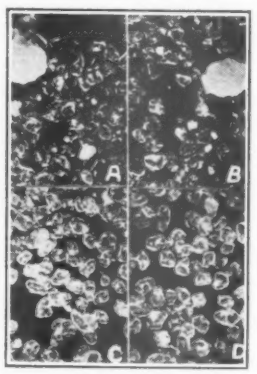


Fig. 15.—Oil-immersed Sand Samples show up the Clay Content under the Microscope.

by examining Fig. 15. The fact that the outlines of the grains are distinct, indicates that they are lightly coated with clay. If they were

(*Continued on page* 264.)

# THE WONDERFUL "HERRMANN" STOVE

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# This Week's News in Brief.

## Trade Talk.

The South Bank shipyard of Messrs. Smith's Dock Company, Limited, was reopened last week.

The British Aluminium Company, Limited, Adelaide House, King William Street, London, E.C.4, have removed from their Birmingham office and warehouse at 21, Barwick Street, to Lawley and Landor Streets. The new telephone number is, Aston Cross 5865-6.

There was a slight improvement in iron and steel output in Czecho-Slovakia during February. The output of pig-iron was 24,733 metric tons (33,138 tons in January), and of crude steel 56,018 tons (52,266 tons in January). The outputs in February, 1932, were 47,000 and 63,000 tons respectively.

Messrs. R. & A. Main, Limited, Gothic Ironworks, Falkirk, have been granted permission by the Falkirk Dean of Guild Court to make an extension to their moulding shop. The addition will be about 270 ft. by 30 ft., and it is anticipated that a considerable number of additional moulders will be employed.

Messrs. Mavor & Coulson, Limited, Glasgow, have on hand more work than they have had for 15 months, and with a night shift and additional men at work the opinion is stated that there is every reason for everyone to be in good spirits. During the past year employment was stabilised for 86.4 per cent. of the employees on the wages books.

Mr. Frank S. Russell (the chairman), addressing the shareholders of General Refractories, Limited, at the annual meeting in Sheffield, said that the company had during the year made a large extension of its manufacturing facilities, and had now five brickworks on which to rely for supplies. They were busily engaged in installing a plant that would make goods at least equal to the best that the United States and the Continent could produce, and he confidently expected this to result in a great accession of business, especially from abroad.

Negotiations are proceeding between the North British Aluminium Company, Limited, and the Transport and General Workers' Union over wage cuts which the company put into operation at Fort William, Foyers, Kinlochleven and Burntisland. About 1,500 workers are affected. The union considers the reduction unwarranted, and, although the company refused to discuss the matter with the union representatives at London headquarters, a Glasgow official of the union has visited the local managers in the districts affected and made representations.

Sir Herbert Lawrence, chairman of Messrs. Vickers, Limited, stated at the annual meeting in London recently, that although the Darlintgon Forge works were closed, when trade improved sufficiently the company would again operate as an important branch of the English Steel Corporation's activities. An undertaking had been given to the Admiralty and to other important customers of the Darlington Forge that the plant would be maintained in its present state for at least three years, during which time it was hoped that conditions might be such as to warrant reopening.

The report for 1932 of the Lancashire Steel Corporation, Limited, states that throughout the year the development of the Irlam Works continued. The coke ovens and by-products plant commenced to operate with satisfactory results, although the plant is not yet working to its full capacity. According to the arrangement with the Manchester Ship Canal Company, the wharf with its unloading equipment was completed, and is now receiving regular shipments of raw materials. The Corporation thus has direct access to the sea. The steel furnaces which have been modernised, together with two blast furnaces, worked continuously throughout the year. Two entirely new steel furnaces have been built, one of which is now in operation. A third blast furnace has been converted for the manufacture of ferro-manganese, and is now producing. A new tarmacadam plant has recently been erected, and this is now going into operation. Alterations to the rolling mills are still proceeding. The report recalls that, in accordance with the policy contemplated for the development of the Irlam Works, the directors decided to install a new wire-rod rolling mill, which will be in operation by June. The report also recalls the purchase through Rylands Bros. of the share capital of the Whitecross Company, Limited, Warrington, thus enabling these two companies to work in the closest collaboration with the Corporation.

## Company Reports.

**Lancashire Steel Corporation, Limited.**—Net earnings, £50,454; carried forward, £52,705.

**Robert Stephenson & Company, Limited.**—Dividend of 4 per cent. for the year.

**Neepsend Steel & Tool Corporation, Limited.**—Interim dividend of 2½ per cent. on the ordinary shares.

**Stanton Ironworks Company, Limited.**—Half-year's dividend on the 6 per cent. cumulative preference shares.

**Craven Bros. (Manchester), Limited.**—Net profit, £5,752; debit balance brought in, £19,767; debit balance forward, £14,015.

**A. Reyrolle & Company, Limited.**—Net profit, £104,285; brought in, £72,521; dividend of 12½ per cent. on the ordinary shares; carried forward, £96,511.

**Associated Electrical Industries, Limited.**—Profit, £474,359; brought in, £99,899; income-tax allowance, £130,888; depreciation, £78,564; ordinary dividend of 4 per cent.; carried forward, £102,415.

**Stewarts & Lloyds, Limited.**—The directors announce the dividends on the first, second and third preference shares for the half-year ended December 31 last, but they have decided to recommend that no dividend be paid on the deferred shares or on the liaison deferred shares for 1932.

## New Companies.

**Milton Foundry, Limited.**—Capital £500. Director: A. T. Browne, 80, Heythorp Street, London, S.W.18.

**J. Shaw (West Hartlepool), Limited,** Longhill Iron Yard, West Hartlepool.—Capital £1,000. Scrap merchants. Director: J. Shaw.

**R. R. Knight, Limited,** 27, Walbrook, London, E.C.4.—Capital £1,000. Ironfounders, etc. Directors: S. C. and S. H. Lait.

**Beasley French & Company, Limited.**—Capital £2,725. Ironfounders. Subscriber: W. J. Phillips, Prospect House, Yarm-on-Tees.

**Felix Kuhn, Limited,** 33, Everton Brow, Liverpool.—Capital £5,000. Iron and brass founders. Directors: M. W. and Mrs. A. Kuhn.

**E. L. Youngleson, Limited,** 67-69, Chancery Lane, London, W.C.2.—Capital £1,000. Ironfounders, etc. Directors: E. L. Youngleson and H. D. Stuart.

**Jeffbairn Castings, Limited.**—Capital £500. Metal founders. Directors: T. W. Fairbairn, 52, Beechwood Road, Sanderstead, Surrey; A. K. Jeffrey.

**John M. Dempster, Limited,** 7, Midland Street, Glasgow, C.1.—Capital £1,000. Iron and steel merchants. Directors: J. M. and Mrs. S. Dempster.

**E. A. Foulds, Limited,** Albert Works, Wordsworth Road, Colne, Lancs.—Capital £1,000. Ironfounders. Directors: E. A. Foulds, R. H. Foulds, and W. G. Foulds.

**Dartmouth Auto Castings, Limited.** — Capital £10,000. Directors: P. Pritchard, Merriemont, Watling Street, Barnt Green; C. C. Maudsley and H. J. Owen.

**Ernest Walters & Company, Limited,** 5, Ash Road, Hartley, near Longfield, Kent.—Capital £100. Ironfounders. Directors: E. W. Spicer and R. J. Wright.

**Carntyne Steel Castings Company, Limited,** Moorpark, Renfrew.—Capital £10,000. Directors: A. C. Brown, J. G. and Mrs. M. M. Wilson and A. W. Jeffrey.

**Schiess-Defries (Great Britain), Limited.**—Capital, £2,000. Machine-tool manufacturers. Solicitor: A. M. Oppenheimer, 31, Queen Victoria Street, London, E.C.4.

**F. R. Cass, Limited,** Britannia Foundry & Garden Works, Barnbrook Street, Bury.—Capital £5,000. Engineers. Directors: F. R. and H. B. Cass and H. S. Holden.

**Chemiemetals, Limited.**—Capital £1,000. Chemical manufacturers, metallurgists, etc. Solicitors: Kenneth Brown, Baker, Baker, Essex House, Essex Street, London, W.C.2.

**Muir Machine Tools, Limited,** Britannia Ironworks, Sherbourne Street, Strangeways, Manchester.—Capital £30,000. Directors: C. A., V. C. N. and W. B. Wood, P. T. Wardle.

**B. H. A. Production, Limited,** Mafeking Road, Smethwick.—Capital £60,000. Stove and furnace manufacturers. Directors: Sir T. H. Spencer, J. T. Brockhouse and T. G. Bedwell.

## Personal.

Mr. J. C. Little, of Newcastle, has been elected President of the Amalgamated Engineering Union, in succession to Mr. W. H. Hutchinson.

Mr. W. B. Pickering, a director of Messrs. Hadfields, Limited, Sheffield, has been elected President of the Sheffield Chamber of Commerce.

Mr. H. Mayhew, after six years' service with Messrs. Palmers Shipbuilding & Iron Company, Limited, Jarrow, in the sales department, has been appointed to the sales staff of the Skinningrove Iron & Steel Company, Limited.

Mr. and Mrs. James Reid, of Loch View, Coltness, have celebrated the fiftieth anniversary of their wedding. Mr. Reid served an apprenticeship as an engineer with the Coltness Iron Company, Limited, in whose service he has been the whole of his life, with the exception of about seven years when he was foreman engineer with the Pather Iron & Steel Company, Limited, of Wishaw.

Mr. James Macaulay, well known to all who visited the Dalzell Steel and Iron Works of Messrs. Colvilles, Limited, Motherwell, has retired after 32 years' service with the firm, and to mark the occasion he was entertained in the works office. Mr. J. M. Colville, works manager, on behalf of the works and staff, presented Mr. Macaulay with a gold watch, a wallet of notes and an umbrella, together with a handbag for Mrs. Macaulay. The inspectors and surveyors who visited the works also presented Mr. Macaulay with a tobacco jar filled with his favourite blend.

Mr. T. E. Upjohn, of Messrs. Stewarts & Lloyds, Limited, retired at the end of March after about 55 years' service with the company. Mr. Upjohn started his career at the Coombs Wood Works, then conducted under the name of Henry Howard & Company. The firm was shortly afterwards merged in that of Lloyd & Lloyd, and Mr. Upjohn was transferred to the Birmingham office. At the time of the amalgamation with Stewarts & Menzies, in 1903, Mr. Upjohn occupied the position of commercial manager, and has acted in the same capacity on the Birmingham side of the business of Stewarts & Lloyds, Limited, up to the time of his retirement. He was made a local director of the company in 1921. Mr. Upjohn has taken an active interest in the work of the Birmingham Chamber of Commerce, and has been a member of the Council for some years. He represented his company on the Council of the Society of British Gas Industries for a considerable time. It is of interest to note that the staff at the Birmingham offices numbered about 25 when Mr. Upjohn was transferred from the Coombs Wood Works. To-day it numbers over 300.

### Wills.

| | |
|---|---|
| Lobnitz, Sir Frederick Carl, engineer and shipbuilder, Renfrew ... ... | £47,444 |
| Neilson, George, a director of the Summerlee Iron Company, Limited ... | £189,607 |
| Warren, Timothy, of Glasgow, chairman of Messrs. William Dixon, Limited ... | £217,689 |
| Strachan, R. P., formerly managing director of Messrs. Strachan & Henshaw, Limited, engineers, Bristol ... | £55,368 |
| Roberts, H. Wynne, director and sales manager of the General Electric Company, Limited ... ... ... ... | £18,792 |
| Parkin, T., governing director of the Moston Malleable Castings Company, Limited, Newton Heath, Manchester | £33,069 |
| Sidebottom, Col. W., of Broadbottom, Cheshire, formerly chairman of Messrs. Cammell, Laird & Company, Limited ... ... ... ... ... | £162,114 |

Pipe manufacturers in Czecho-Slovakia are awaiting the official particulars as regards specifications and prices in connection with the recent Russian contract for 70,000 tons of pipes and pipe fittings. Whereas the German Government have undertaken to provide an export guarantee of 65 per cent., it is not yet clear whether the Czecho-Slovak Government will provide similar guarantees or to what extent they will be prepared to support manufacturers. In these circumstances the proportion of the quota to be taken up by Czecho-Slovakia is still doubtful. In view of the unfavourable terms of payment (four years' credit), Czecho-Slovak works do not attach undue importance to the contract. When the Government's attitude is known, a decision will be taken as to whether Czecho-Slovakia shall take advantage of the quota allotted to her, or only a part thereof, applying for compensation in the form of other contracts from countries other than Russia to fill the quota.

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THE MOULD is lowered from the turnover table by a central piston, working inside the jarring piston, and is therefore perfectly true and cannot get out of line.

THE PATTERN DRAWING PISTON being operated by oil through pneumatic pressure gives a perfect draw, thus castings of absolute uniformity are obtained.

The moulds being large and heavy are withdrawn by means of a ball-bearing trolley on extension lines as shown in the illustration opposite.

THE TURNOVER TABLE is cranked to help balance when being turned over.

STEEL CASTINGS are used for turnover table, pattern drawing table and piston, jolting table and side column brackets.

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# Raw Material Markets.

Trading in the iron and steel markets is still considerably restricted, but the pulse of activity seems to be quickening slightly. Steady buying of pig-iron has been seen, whilst the finished-steel market is marked by moderate activity. The placing of a few shipbuilding specifications by the yards has improved the position slightly. Government "economy" restrictions on local development schemes are holding up a considerable volume of trade.

## Pig-Iron.

**MIDDLESBROUGH.**—New pig-iron business is limited, but regular deliveries are being made against contracts. The producers are now in a much more favourable position than they have occupied for some time, and an optimistic view is taken of the future. One local firm is reported to have reduced its stocks since the beginning of the year by approximately 20,000 tons. Of the two blast furnaces restarted recently at the Skinningrove Works, one is now stated to be producing a special steelmaking iron for domestic use, so that there are actually only two furnaces turning out Cleveland iron for merchanting purposes. The export market is slightly more active, although prices are cut very fine in this direction, there being no control. Scottish deliveries are being made on the minimum basis of No. 3 Cleveland G.M.B. 62s. 9d. per ton delivered Glasgow, which compares with a delivered price of 62s. 6d. in the Middlesbrough area and 64s. 6d. to North-East Coast destinations. The makers' scale provides for a premium of 2s. 6d. per ton for No. 1 Cleveland foundry iron and a discount of 1s. per ton for No. 4 foundry or No. 4 forge.

East Coast hematite, owing to its low price, is attracting considerable attention, and substantial sales have been to Scotland, Sheffield and, to a smaller extent, South Wales. The output of the seven furnaces is going promptly into consumption. Mixed numbers are quoted on the market at 59s. per ton and No. 1 quality at 59s. 6d. per ton.

**LANCASHIRE.**—New business is almost entirely on month-to-month lines, only a few of the larger users being able to look two or three months ahead. Aggregate deliveries into consumption are only being maintained with difficulty. Some of the light-castings makers in this district are slightly busier, but work at the general foundries shows no improvement. Pig-iron prices are steady all round, Staffordshire and Derbyshire No. 3 being on offer for delivery to works in the Manchester zone at 67s. per ton, Northamptonshire at 65s. 6d., Derbyshire forge iron at 62s., Scottish foundry at around 82s., West Coast hematite at about 80s. 6d. and East Coast hematite at 5s. less. Cleveland No. 3 is quoted for delivery in the Manchester zone on the same basis as the Midland makes, but there is little call for this material locally.

**MIDLANDS.**—Consumers still limit their orders to small quantities for immediate delivery, and see no reason to change their policy, in view of the large stocks in hand at the furnaces. The current prices for Midland brands, including delivery to Birmingham and Black Country stations, are 62s. 6d. for Northants No. 3 and 66s. for Derbyshire, North Staffordshire, Lincolnshire and Cleveland No. 3. Medium and low-phosphorus irons are available in the Black Country at from 69s. to 85s. per ton.

**SCOTLAND.**—Business is dull. There is more activity at one or two of the engineering foundries, but, generally speaking, there is much idle plant. Few light-castings makers are working more than three or four days a week. There is no change in prices and the official minimum of 65s. for No. 3 foundry at furnaces is maintained, with an extra 2s. 6d. per ton for No. 1. No. 3 Middlesbrough is quoted at 62s. 9d. per ton at Glasgow and 59s. 9d. at Falkirk. Other English irons are quoted at 2s. 3d. less, by arrangement.

## Coke.

Conditions remain dull in the foundry-coke market. Prices have now been unchanged for a period of many months. Best Durham coke is quoted at 36s. 6d. to 38s. 6d. per ton with other grades at 2s. 6d. per ton less. Welsh cokes range from 30s. to 46s. per ton, delivered Birmingham and district.

## Steel.

British manufacturers of semi-finished steel have been slightly busier lately, having benefited somewhat from the withdrawal of Continental competitors from the market. Finished-steel business has improved slightly, and both consumers and stockholders have been more willing to come to terms. Export inquiries have also been more promising, whilst considerable benefits should result from the trade agreements which are expected to be concluded with Argentina and Scandinavia.

## Scrap.

The Cleveland scrap market is distinctly easier at the moment. Ordinary cast-iron scrap is at 42s. 6d. per ton, machinery quality being at 45s. Light castings are on offer at 37s. 6d. per ton delivered. In the Midlands, there is a steady demand from the local ironfounders. For heavy machinery metal in handy sizes 47s. 6d. per ton is paid, for good heavy iron in cupola sizes 42s. 6d. to 45s., and for clean light metal 39s., delivered works. Heavy cast iron is offering more freely in South Wales, and is easier at 44s. per ton. Light cast iron is now at 38s. to 39s., machinery scrap having a limited sale at 48s. to 50s. The demand for scrap iron has fallen off in Scotland, and it is difficult to find buyers for machinery metal at 50s. to 51s. 3d. Ordinary cast iron, in pieces not exceeding 1 cwt., is at about 46s. 6d. per ton, delivered f.o.t. consumers' works.

## Metals.

**Copper.**—The rumour that a complete shut-down of all the American mines is contemplated has been responsible for a considerable firming-up in prices and a more optimistic tone has been general. A number of cables have since come through announcing definite decisions to close down individual mines. Inquiries from consumers have also been more active, but there has been no improvement in the general rate of consumption.

Prices have been :—

*Cash.*—Thursday, £29 to £29 2s. 6d.; Friday, £29 8s. 9d. to £29 10s.; Monday, £29 12s. 6d. to £29 15s.; Tuesday, £30 to £30 1s. 3d.

*Three Months.*—Thursday, £29 6s. 3d. to £29 7s. 6d.; Friday, £29 13s. 9d. to £29 15s.; Monday, £29 15s. to £29 17s. 6d.; Tuesday, £30 3s. 9d. to £30 5s.

**Tin.**—Messrs. Rudolf Wolff & Company state that the market "has been firm. Business with consumers has been fairly well maintained in this country and on the Continent, whilst very active conditions have on the whole been reported in the United States of America. The firmness of the market may be taken as an indication of returning confidence, fostered by the gradual improvement in the statistical position which has taken place in the last months, and the future is regarded with growing optimism in the belief that, under the control which is exercised over output and stocks, the fundamental position will continue to develop favourably, and were the general industrial situation to give any evidence of very definite improvement, a marked recovery in prices would ensue."

Prices of standard tin have been :—

*Cash.*—Thursday, £153 15s. to £153 17s. 6d.; Friday, £154 15s. to £155; Monday, £156 to £156 5s.; Tuesday, £156 7s. 6d. to £156 10s.

*Three Months.*—Thursday, £154 12s. 6d. to £154 15s.; Friday, £155 10s. to £155 15s.; Monday, £156 17s. 6d. to £157; Tuesday, £157 to £157 5s.

**Spelter.**—A somewhat wider inquiry has been seen from the consuming industries, whose position, however, has shown little improvement, speaking generally. Brassmakers, both here and on the Continent, are reported to be doing slightly better, however. Market sentiment has improved in sympathy with the other metals.

Price fluctuations :—

*Ordinary.* — Thursday, £14 15s.; Friday, £14 17s. 6d.; Monday, £15 1s. 3d.; Tuesday, £14 17s. 6d.

**Lead.**—Messrs. Brandeis, Goldschmidt & Company report that "there has been rather a better demand for lead from the Continent, and the London market has remained quite steady throughout the week. In this country there has also been a good inquiry and in some parts of the trade the outlook for the future is favourable. The price of lead on the London market is affected to some extent by the 10 per cent. tariff, which has caused a certain amount of foreign lead to be warehoused in bond in this country, and this tends to have a slightly depressing influence on the market."

Daily market prices :—

*Soft Foreign (Prompt).*—Thursday, £10 10s.; Friday, £10 13s. 9d.; Monday, £10 15s.; Tuesday, £11.

## The Sand Question in Regard to Light-Casting Production.

(*Continued from page* 260.)

perfectly clean they would be indistinguishable from the oil. The clear white patches in the two upper photographs are clay, and it is interesting to note how the clay gradually coats the transparent sand grains as milling progresses, as indicated by the grains standing out in greater relief. The milling times are as follows:—A—1½ mins., B—3 mins., C—6 mins., D—9 mins.

These photographs were taken with a binocular type microscope, the use of which is practically essential in the examination of sands in order to obtain the necessary depth of field. Whilst this method of examination may not at present be applicable to the examination of all sands, it has proved of value in the study of bond distribution by milling, and this distribution is a function of the grain size of the sand as well as of milling time. Dierker's work definitely shows that the finer the texture of the sand the longer the milling time required to effect uniform distribution of the clay bond. Using a silica sand of varying grain sizes plus 10 per cent. of fireclay, it was found that the clay was uniformly distributed in 1 to 3 mins. for a sand having a grain size between 20 to 28 mesh, whilst it required a milling time of 9 to 11 mins. to effect the distribution in a sand of 65 to 100 mesh.

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(*To be concluded.*)

## Calendars Received.

Two firms, August's, Limited, of Halifax, and Metropolitan-Vickers, Limited, of Trafford Park, like to be a little different from the rest, and send out their calendars just when the Christmas batch are looking a little soiled. While the former is of the utilitarian variety and can be read with ease in a fair-sized office, the latter is of artistic merit and portrays in colours Miss Phyllis Stanley, of "The Miracle" fame. Metropolitan-Vickers have been brightening up industrial offices with their calendars for many years now, and we have learned to look forward to this much-appreciated courtesy.

XUM

# HERE'S THE LINER

# FRODAIR PIG IRON

Best after Test

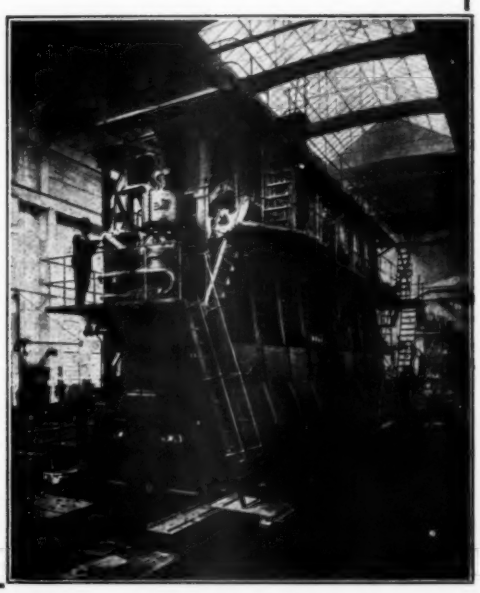
50 YEARS

## THERE'S THE ENGINE

8 Cyl. 4 Stroke Diesel Marine Engine

3,200 H.P. Frodair Pig Iron

*(Customer's Photos.)*



**FRODAIR IRON & STEEL Co., Ltd.,**

**FENCHURCH HOUSE,**

**LONDON.**

# WEEKLY PRICE CURRENT.

## COPPER.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 30 | 0 | 0 |
| Three months | 30 | 3 | 9 |
| Electrolytic | 34 | 15 | 0 |
| Tough | 32 | 0 | 0 |
| Best selected | 32 | 10 | 0 |
| Sheets | 61 | 0 | 0 |
| India | 43 | 0 | 0 |
| Wire bars | 35 | 0 | 0 |
| Do., May | 34 | 17 | 6 |
| Do., June | 34 | 15 | 0 |
| Ingot bars | 35 | 0 | 0 |
| H.C. wire rods | 37 | 0 | 0 |
| Off. av. cash, March | 28 | 4 | 4 1/3 |
| Do., 3 mths., March | 28 | 9 | 10 1/3 |
| Do., Sttlmnt., March | 28 | 4 | 2 2/3 |
| Do., Electro, March | 32 | 13 | 3 2/3 |
| Do., B.S., March | 31 | 0 | 3 1/3 |
| Do., wire bars, March | 32 | 17 | 2 2/3 |
| Solid drawn tubes | | | 9½d. |
| Brazed tubes | | | 9½d. |
| Wire | | | 6½d. |

## BRASS.

| | |
|---|---|
| Solid drawn tubes | 8¾d. |
| Brazed tubes | 10¾d. |
| Rods, drawn | 7¾d. |
| Rods, extd. or rlld. | 4¾d. |
| Sheets to 10 w.g. | 7⅝d. |
| Wire | 7¼d. |
| Rolled metal | 6⅞d. |
| Yellow metal rods | 4¼d. |
| Do. 4 × 4 Squares | 5¼d. |
| Do. 4 × 3 Sheets | 5¼d. |

## TIN.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 156 | 7 | 6 |
| Three months | 157 | 0 | 0 |
| English | 157 | 15 | 0 |
| Bars | 159 | 15 | 0 |
| Straits | 162 | 5 | 0 |
| Australian | 159 | 10 | 0 |
| Eastern | 162 | 5 | 0 |
| Banca | 163 | 0 | 0 |
| Off. av. cash, March | 149 | 4 | 1 1/3 |
| Do., 3 mths., March | 149 | 18 | 1 4/5 |
| Do., Sttlmt., March | 149 | 4 | 1 1/3 |

## SPELTER.

| | £ | s. | d. |
|---|---|---|---|
| Ordinary | 14 | 17 | 6 |
| Remelted | 14 | 15 | 0 |
| Hard | 12 | 10 | 0 |
| Electro 99.9 | 17 | 15 | 0 |
| English | 15 | 17 | 6 |
| India | 14 | 0 | 0 |
| Zinc dust | 19 | 5 | 0 |
| Zinc ashes | 2 | 5 | 0 |
| Off. aver., March | 14 | 13 | 2 1/3 |
| Aver. spot, March | 14 | 12 | 11 4/3 |

## LEAD.

| | £ | s. | d. |
|---|---|---|---|
| Soft foreign ppt. | 11 | 0 | 0 |
| Empire | 11 | 0 | 0 |
| English | 12 | 10 | 0 |
| Off. average, March | 10 | 14 | 3 1/3 |
| Average spot, March | 10 | 12 | 2 3/3 |

## ZINC SHEETS, &c.

| | £ | s. | d. |
|---|---|---|---|
| Zinc sheets, English | 24 | 0 | 0 |
| Do., V.M. ex-whse. | 23 | 5 | 0 |
| Rods | 26 | 0 | 0 |
| Boiler plates | 22 | 0 | 0 |
| Battery plates | | | — |

## ANTIMONY.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| English | 37 | 10 | 0 to | 42 | 10 | 0 |
| Chinese | | | | 26 | 10 | 0 |
| Crude | | | | | | — |

## QUICKSILVER.

| | £ | s. | d. |
|---|---|---|---|
| Quicksilver | 9 | 7 | 6 |

## FERRO-ALLOYS AND STEEL-MAKING METALS.

| | £ | s. | d. |
|---|---|---|---|
| Ferro silicon— | | | |
| 25% | 7 | 15 | 0 |
| 45/50% | 13 | 17 | 6 |
| 75% | 19 | 12 | 6 |
| Ferro-vanadium— | | | |
| 35/50% | 12/8 lb. Va. | | |
| Ferro-molybdenum— | | | |
| 70/75% carbon-free of Mo. | 6/3 per lb. | | |
| Ferro-titanium— | | | |
| 23/25% carbon-free | 10d. lb. | | |
| Ferro-phosphorus, 20/25% | £17 | 17 | 6 |
| Ferro-tungsten— | | | |
| 80/85% | 1/7½ lb. | | |
| Tungsten metal powder— | | | |
| 98/99% | 1/10½ lb. | | |
| Ferro-chrome— | | | |
| 2/4% car. | £29 | 5 | 0 |
| 4/6% car. | £22 | 15 | 0 |
| 6/8% car. | £21 | 15 | 0 |
| 8/10% car. | £21 | 0 | 0 |
| Ferro-chrome— | | | |
| Max. 2% car. | £34 | 10 | 0 |
| Max. 1% car. | £36 | 5 | 0 |
| Max. 0.70% car. | £40 | 2 | 6 |
| 70% carbon-free | 11d. lb. | | |
| Nickel—99.5/100% | £240 to £245 | | |
| "F" nickel shot | £216 | 0 | 0 |
| Ferro-cobalt | 7/3 lb. | | |
| Aluminium 98/99% | £100 | 0 | 0 |
| Metallic chromium— | | | |
| 96/98% | 2/8 lb. | | |
| Ferro-manganese (net)— | | | |
| 76/80% loose | £10 15 0 to £11 | 5 | 0 |
| 76/80% packed | £11 15 0 to £12 | 5 | 0 |
| 76/80% export | (nom.) £9 | 15 | 0 |
| Metallic manganese— | | | |
| 94/96% carbon-free | 1/4 lb. | | |

Per ton unless otherwise stated.

## HIGH-SPEED TOOL STEEL.

| | |
|---|---|
| Finished bars, 14% tungsten | 2s. 0d. |
| Finished bars, 18% tungsten | 2s. 9d. |

Per lb. net, d/d buyers' works.

| | |
|---|---|
| Extras— | |
| Rounds and squares, 3 in. and over | 4d. lb. |
| Rounds and squares, under ½ in. to ¼ in. | 3d. lb. |
| Do., under ¼ in. to 1/16 in. | 1/– lb. |
| Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in. | 3d. lb. |
| Do., under ½ in. × ¼ in. | 1/– lb. |
| Bevels of approved sizes and sections | 6d. lb. |

Bars cut to length, 10% extra.

## SCRAP.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| South Wales— | | | | | | |
| Heavy steel | 2 | 3 | 6 to | 2 | 5 | 0 |
| Bundled steel and shrngs. | 1 | 15 | 0 to | 2 | 1 | 6 |
| Mixed iron and steel | 1 | 19 | 0 to | 2 | 1 | 0 |
| Heavy cast iron | | | | 2 | 4 | 0 |
| Good machinery | 2 | 8 | 0 to | 2 | 10 | 0 |
| Cleveland— | | | | | | |
| Heavy steel | | | | 2 | 0 | 0 |
| Steel turnings | | | | 1 | 12 | 6 |
| Cast-iron borings | | | | 1 | 3 | 6 |
| Heavy forge | | | | 2 | 10 | 0 |
| W.I. piling scrap | | | | 2 | 2 | 6 |
| Cast-iron scrap | 2 | 2 | 6 to | 2 | 5 | 0 |
| Midlands— | | | | | | |
| Light cast-iron scrap | | | | 1 | 19 | 0 |
| Heavy wrought iron | | | | 2 | 10 | 0 |
| Steel turnings, f.o.r. | | | | 1 | 5 | 6 |
| Scotland— | | | | | | |
| Heavy steel | 1 | 17 | 6 to | 1 | 18 | 9 |
| Ordinary cast iron | | | | 2 | 6 | 6 |
| Engineers' turnings | | | | 1 | 11 | 6 |
| Cast-iron borings | | | | 1 | 12 | 6 |
| Wrought-iron piling | | | | 2 | 5 | 0 |
| Heavy machinery | 2 | 10 | 0 to | 2 | 11 | 3 |

London—Merchants' buying prices, delivered yard.

| | £ | s. | d. |
|---|---|---|---|
| Copper (clean) | 21 | 0 | 0 |
| Brass | 16 | 0 | 0 |
| Lead (less usual draft) | 9 | 0 | 0 |
| Tea lead | 7 | 10 | 0 |
| Zinc | 8 | 0 | 0 |
| New aluminium cuttings | 74 | 0 | 0 |
| Braziery copper | 19 | 0 | 0 |
| Gunmetal | 18 | 0 | 0 |
| Hollow pewter | 80 | 0 | 0 |
| Shaped black pewter | 60 | 0 | 0 |

## PIG-IRON.

*(f.o.t. unless otherwise stated.)*

| | |
|---|---|
| N.E. Coast (d/d Tees-side area)— | |
| Foundry No. 1 | 65/– |
| Foundry No. 3 | 62/6 |
| ,, at Falkirk | 59/9 |
| ,, at Glasgow | 62/9 |
| Foundry No. 4 | 61/6 |
| Forge No. 4 | 61/6 |
| Hematite No. 1, f.o.t. | 59/6 |
| Hematite M/Nos., f.o.t. | 59/– |
| N.W. Coast— | |
| Hem. M/Nos. d/d Glas. | 68/6 |
| ,, d/d Birm. | 84/6 |
| Malleable iron d/d Birm. | 115/– |
| Midlands (d/d Birmingham dist.)— | |
| Staffs No. 4 forge | 62/– |
| ,, No. 3 fdry. | 66/– |
| Northants forge | 58/6 |
| ,, fdry. No. 3 | 62/6 |
| ,, fdry. No. 1 | 65/6 |
| Derbyshire forge | 62/– |
| ,, fdry. No. 3 | 66/– |
| ,, fdry. No. 1 | 69/– |
| Scotland— | |
| Foundry No. 1 | 67/6 |
| ,, No. 3 | 65/– |
| Hem. M/Nos. d/d | 66/– |
| Sheffield (d/d district)— | |
| Derby forge | 59/6 |
| ,, fdry. No. 3 | 63/6 |
| Lincs forge | 59/6 |
| ,, fdry. No. 3 | 63/6 |
| E.C. hematite | 73/6 |
| W.C. hematite | 83/6 |
| Lancashire (d/d eq. Man.)— | |
| Derby fdry. No. 3 | 67/– |
| Staffs fdry. No. 3 | 67/– |
| Northants fdry. No. 3 | 65/6 |
| Cleveland fdry. No. 3 | 67/– |
| Dalzell, No. 3 (special) | 102/6 to 105/– |
| Glengarnock, No. 3 | 82/– |
| Clyde, No. 3 | 82/– |
| Monkland, No. 3 | 82/– |
| Summerlee, No. 3 | 82/– |
| Eglinton, No. 3 | 82/– |
| Gartsherrie, No. 3 | 82/– |
| Shotts, No. 3 | 82/– |

## FINISHED IRON AND STEEL.

*Usual district deliveries for iron; delivered consumer's station for steel.*

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Iron— | | | | | | |
| Bars (cr.) | 9 | 0 | 0 to | 9 | 15 | 0 |
| Nut and bolt iron | 7 | 10 | 0 to | 8 | 0 | 0 |
| Hoops | 10 | 10 | 0 to | 12 | 0 | 0 |
| Marked bars (Staffs) f.o.t. | | | | 12 | 0 | 0 |
| Gas strip | 10 | 10 | 0 to | 12 | 0 | 0 |
| Bolts and nuts, ¾ in. × 4 in. | | | | 12 | 15 | 0 |
| Steel— | | | | | | |
| Plates, ship, etc. | 8 | 15 | 0 to | 8 | 17 | 6 |
| Boiler plts. | 8 | 0 | 0 to | 9 | 0 | 0 |
| Chequer plts. | | | | 10 | 7 | 6 |
| Angles | | | | 8 | 7 | 6 |
| Tees | | | | 9 | 7 | 6 |
| Joists | | | | 8 | 15 | 0 |
| Rounds and squares, 3 in. to 5½ in. | | | | 9 | 7 | 6 |
| Rounds under 3 in. to ¾ in. (Untested) | 6 | 15 | 0 & up. | | | |
| Flats—8 in. wide and over | | | | 8 | 12 | 6 |
| ,, under 8 in. and over 5 in. | | | | 8 | 17 | 6 |
| Rails, heavy | 8 | 5 | 0 to | 8 | 10 | 0 |
| Fishplates | | | | 12 | 0 | 0 |
| Hoops (Staffs) | 9 | 10 | 0 & up. | | | |
| Black sheets, 24g. (10-t. lots) | 9 | 10 | 0 | | | |
| Galv. cor. shts. ,, | | | | 11 | 15 | 0 |
| Galv. flat shts. ,, | | | | 12 | 5 | 0 |
| Galv. fencing wire, 8g. plain | | | | 14 | 0 | 0 |
| Billets, soft | 5 | 0 | 0 to | 5 | 7 | 6 |
| Billets, hard | 6 | 12 | 6 to | 7 | 2 | 6 |
| Sheet bars | 4 | 15 | 0 to | 5 | 2 | 6 |
| Tin bars | | | | 4 | 15 | 0 |

## PHOSPHOR BRONZE.

| | Per lb. basis. |
|---|---|
| Strip | 10½d. |
| Sheet to 10 w.g. | 11½d. |
| Wire | 11⅝d. |
| Rods | 10½d. |
| Tubes | 15d. |
| Castings | 12½d. |

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

## NICKEL SILVER, &c.

| | Per lb. |
|---|---|
| Ingots for raising | 7d. to 1/1 |
| Rolled— | |
| To 9 in. wide | 1/1 to 1/7 |
| To 12 in. wide | 1/1½ to 1/7½ |
| To 15 in. wide | 1/1½ to 1/7½ |
| To 18 in. wide | 1/2 to 1/8 |
| To 21 in. wide | 1/2½ to 1/8½ |
| To 25 in. wide | 1/3 to 1/9 |
| Ingots for spoons and forks | 7d. to 1/3½ |
| Ingots rolled to spoon size | 10d. to 1/6½ |
| Wire round— | |
| to 10g. | 1/4½ to 1/11½ |

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

## AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2 foundry, Phila. | 13.34 |
| No. 2 foundry, Valley | 14.50 |
| No. 2 foundry, Birm. | 11.00 |
| Basic | 15.39 |
| Bessemer | 16.89 |
| Malleable | 16.39 |
| Grey forge | 16.39 |
| Ferro-mang. 80%, seaboard | 68.00 |
| O.-h. rails, h'y, at mill | 40.00 |
| Billets | 26.00 |
| Sheet bars | 26.00 |
| Wire rods | 35.00 |
| | Cents. |
| Iron bars, Phila. | 1.86 |
| Steel bars | 1.60 |
| Tank plates | 1.60 |
| Beams, etc. | 1.60 |
| Skelp, grooved steel | 1.60 |
| Steel hoops | 1.55 |
| Sheets, black, No. 24 | 2.00 |
| Sheets, galv., No. 24 | 2.60 |
| Wire nails | 1.85 |
| Plain wire | 2.10 |
| Barbed wire, galv. | 2.35 |
| Tinplates, 100-lb. box | $4.25 |

## COKE (at ovens).

| | |
|---|---|
| Welsh foundry | 20/– to 22/6 |
| ,, furnace | 16/– to 16/6 |
| Durham and Northumberland— | |
| ,, foundry | 21/– to 25/– |
| ,, furnace | 13/3 |
| Midlands, foundry | — |
| ,, furnace | — |

## TINPLATES.

f.o.b. Bristol Channel ports.

| | | |
|---|---|---|
| I.C. cokes | 20×14 per box | 15/6 to 16/– |
| ,, | 28×20 ,, | 31/– to 32/– |
| ,, | 20×10 ,, | 22/3 to 22/9 |
| ,, | 18¾×14 ,, | 16/1½ to 16/4½ |
| C.W. | 20×14 ,, | 14/6 |
| ,, | 28×20 ,, | 30/3 |
| ,, | 20×10 ,, | 22/– |
| ,, | 18⅞×14 ,, | 15/10½ |

## SWEDISH CHARCOAL IRON & STEEL.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Pig-iron | £6 | 0 | 0 to | £7 | 0 | 0 |
| Bars-hammered, basis | £16 | 10 | 0 to | £17 | 0 | 0 |
| Bars and nail-rods, rolled, basis | £15 | 17 | 6 to | £16 | 5 | 0 |
| Blooms | £10 | 0 | 0 to | £12 | 0 | 0 |
| Keg steel | £32 | 0 | 0 to | £33 | 0 | 0 |
| Faggot steel | £18 | 0 | 0 to | £23 | 0 | 0 |
| Bars and rods dead soft, st'l | £10 | 0 | 0 to | £12 | 0 | 0 |

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

## DAILY FLUCTUATIONS.

**Standard Copper** (cash).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 29 0 0 inc. | 15/– |
| ,, 7 .. | 29 8 9 ,, | 8/9 |
| ,, 10 .. | 29 12 6 ,, | 3/9 |
| ,, 11 .. | 30 0 0 ,, | 7/6 |

**Standard Tin** (cash).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 153 15 0 inc. | 5/– |
| ,, 7 .. | 154 15 0 ,, | 20/– |
| ,, 10 .. | 156 0 0 ,, | 25/– |
| ,, 11 .. | 156 7 6 ,, | 7/6 |

**Spelter** (ordinary).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 14 15 0 inc. | 6/3 |
| ,, 7 .. | 14 17 6 ,, | 2/6 |
| ,, 10 .. | 15 1 3 ,, | 3/9 |
| ,, 11 .. | 14 17 6 dec. | 3/9 |

**Zinc Sheets** (English).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 24 0 0 | No change |
| ,, 7 .. | 24 0 0 | ,, ,, |
| ,, 10 .. | 24 0 0 | ,, ,, |
| ,, 11 .. | 24 0 0 | ,, ,, |

**Electrolytic Copper.**

| | £ s. d. | |
|---|---|---|
| April 6 .. | 32 15 0 inc. | 15/– |
| ,, 7 .. | 33 10 0 ,, | 15/– |
| ,, 10 .. | 34 0 0 ,, | 10/– |
| ,, 11 .. | 34 15 0 ,, | 15/– |

**Tin** (English ingots).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 155 0 0 inc. | 5/– |
| ,, 7 .. | 156 5 0 ,, | 25/– |
| ,, 10 .. | 157 5 0 ,, | 20/– |
| ,, 11 .. | 157 15 0 ,, | 10/– |

**Spelter** (Electro, 99.9 per cent.).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 17 5 0 inc. | 5/– |
| ,, 7 .. | 17 10 0 ,, | 5/– |
| ,, 10 .. | 17 15 0 ,, | 5/– |
| ,, 11 .. | 17 15 0 No change | |

**Lead** (English).

| | £ s. d. | |
|---|---|---|
| April 6 .. | 12 0 0 inc. | 5/– |
| ,, 7 .. | 12 5 0 ,, | 5/– |
| ,, 10 .. | 12 5 0 | No change |
| ,, 11 .. | 12 10 0 inc. | 5/– |

## AVERAGE MONTHLY PRICES OF STEEL RAILS.

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Yearly average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| 1918 .. .. | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 | 10 17 6 |
| 1919 .. .. | 10 17 6 | 13 7 6 | 13 7 6 | 13 7 6 | 15 0 0 | 15 10 0 | 16 0 0 | 16 10 0 | 16 10 0 | 16 10 0 | 16 10 0 | 17 5 0 | 14 12 11 |
| 1920 .. .. | 18 15 0 | 19 5 0 | 20 7 6 | 22 0 0 | 23 0 0 | 23 0 0 | 24 0 0 | 25 0 0 | 25 0 0 | 25 0 0 | 25 0 0 | 25 0 0 | 22 18 11½ |
| 1921 .. .. | 23 5 0 | 20 4 0 | 18 0 0 | 17 0 0 | 15 0 0 | 15 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 11 12 6 | 10 10 0 | 10 0 0 | 15 4 3 |
| 1922 .. .. | 9 10 0 | 9 10 0 | 9 10 0 | 9 10 0 | 9 10 0 | 9 10 0 | 9 10 0 | 9 0 0 | 8 15 0 | 8 15 0 | 8 15 0 | 8 15 0 | 9 4 2 |
| 1923 .. .. | 8 17 6 | 9 2 0 | 10 5 0 | 10 10 0 | 10 10 0 | 10 10 0 | 9 15 0 | 9 0 0 | 8 15 0 | 8 15 0 | 8 19 0 | 9 5 0 | 9 9 10 |
| 1924 .. .. | 9 5 0 | 9 5 0 | 9 5 0 | 9 5 0 | 9 5 0 | 9 2 6 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 2 3½ |
| 1925 .. .. | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 8 15 0 | 8 10 7½ | 8 10 0 | 8 10 0 | 8 10 0 | 8 4 0 | 8 0 0 | 8 0 0 | 8 11 7½ |
| 1926 .. .. | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 7 6 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 3 11½ |
| 1927 .. .. | 8 10 0 | 8 10 0 | 8 10 0 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 3 0 | 8 5 0 | 8 5 0 | 8 4 10 |
| 1928 .. .. | 8 5 0 | 8 5 0 | 8 5 0 | 8 5 9 | 8 6 3 | 8 6 3 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 7 9½ |
| 1929 .. .. | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 |
| 1930 .. .. | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 |
| 1931 .. .. | 8 9 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 8 |
| 1932 .. .. | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 |
| 1933 .. .. | 8 7 6 | 8 7 6 | 8 7 6 | — | — | — | — | — | — | — | — | — | — |

## AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE AT MIDDLESBROUGH.

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. | s. d. |
| 1917 .. .. | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 |
| 1918 .. .. | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 | 122 6 |
| 1919 .. .. | 122 6 | 122 6 | 122 6 | 122 6 | 179 2 | 190 0 | 197 6 | 200 0 | 200 0 | 200 0 | 200 0 | 200 0 | 171 4 |
| 1920 .. .. | 220 0 | 220 0 | 240 0 | 260 0 | 260 0 | 260 0 | 260 0 | 260 0 | 260 0 | 260 0 | 260 0 | 260 0 | 251 8 |
| 1921 .. .. | 240 0 | 220 0 | 180 0 | 180 0 | 180 0 | 160 0 | 160 0 | 160 0 | 137 0 | 127 6 | 117 6 | 104 6 | 162 2 |
| 1922 .. .. | 97 6 | 91 7½ | 100 0 | 98 6 | 97 1½ | 94 7 | 93 6 | 90 9 | 89 7 | 91 10½ | 93 0 | 93 2 | 94 5½ |
| 1923 .. .. | 94 6 | 104 9 | 122 0 | 126 10½ | 122 0 | 115 3 | 107 0 | 98 8½ | 98 10½ | 99 1½ | 100 6½ | 102 3 | 107 10½ |
| 1924 .. .. | 102 4½ | 101 3 | 99 7½ | 99 0 | 98 9½ | 97 4½ | 95 3½ | 95 1½ | 90 7½ | 88 0 | 88 4½ | 88 5 | 95 2½ |
| 1925 .. .. | 87 5 | 85 9 | 84 7½ | 82 6 | 80 10½ | 79 3 | 77 1½ | 75 7½ | 75 0 | 74 3½ | 74 9 | 76 0 | 79 5½ |
| 1926 .. .. | 77 3 | 77 9 | 77 3½ | 76 3 | 77 4½ | 78 0 | 79 8½ | 81 9 | 83 4½ | 87 7½ | 92 6 | 90 5½ | 81 7½ |
| 1927 .. .. | 90 0 | 90 0 | 86 3½ | 83 1½ | 80 6 | 78 0 | 76 6 | 75 4½ | 75 0 | 72 9 | 71 9 | 71 1½ | 79 2½ |
| 1928 .. .. | 69 7½ | 69 7½ | 69 9 | 70 0 | 70 0 | 69 3 | 68 7½ | 69 2 | 70 0 | 70 0 | 70 3 | 71 0 | 69 9½ |
| 1929 .. .. | 71 6 | 72 0 | 73 6 | 74 0 | 74 0 | 74 1½ | 74 9 | 75 6 | 76 1½ | 76 8½ | 78 1½ | 79 0 | 74 11½ |
| 1930 .. .. | 78 2½ | 78 0 | 76 9 | 75 0 | 74 0 | 72 7½ | 71 0 | 71 0 | 71 0 | 71 0 | 70 10½ | 70 4½ | 73 3½ |
| 1931 .. .. | 70 0 | 69 0 | 68 0 | 66 8½ | 65 1½ | 63 4½ | 62 9 | 61 1½ | 65 0 | 65 0 | 65 0 | 65 0 | 65 6 |
| 1932 .. .. | 64 10 | 64 3 | 63 6 | 63 6 | 63 6 | 62 7½ | 62 0 | 60 6 | 60 0 | 59 3 | 59 0 | 59 0 | 61 10 |
| 1933 .. .. | 59 0 | 59 0 | 59 0 | — | — | — | — | — | — | — | — | — | — |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|---|---|
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